Naval Research Laboratory
Washington, DC 20375-5320

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Atmospheric Transmittance Between 1.0 and 2.0 μm

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Optical Sciences Division

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Calculated high resolution extinction plots at sea level are presented for the spectral region between 1 and 2 μm using a mid-latitude summer atmospheric model.

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CONTENTS

ATMOSPHERIC TRANSMITTANCE BETWEEN 1.0 AND 2.0 μM

G.L. Trusty and J.A. Welch

INTRODUCTION

In the design of EO systems that operate in the infrared the most important aspect for outdoor use is the choice of wavelength. Because of molecular absorption by atmospheric gases, there are few locations in the infrared spectrum that provide sufficiently high transmission for a system to perform successfully. For laser-based systems, the high complexity of the spectrum usually requires a calculation for each proposed wavelength.

In 1983, primarily driven by calculations required for the HF-DF laser, two members of this section at NRL (Leslie and Lebow) produced a report[1] that provided calculated plots of high-resolution molecular absorption spectra of the composite atmospheric gases from 2.0 to 5.0 μm. These plots were of sufficiently high resolution (40 cm^{-1} total on each 7-inch-long graph) that all spectral structure at one atmosphere of pressure, i.e., at sea level, was readily discernable by the reader. That report proved to be extremely useful; in fact, after these ten years it is still regularly referred to for laser and system choices in that spectral region.

THE CALCULATIONS

In the past several years, new laser developments and new requirements revitalized interest in atmospheric propagation. Over that time we have found many wavelengths being investigated that fall between 1.0 and 2.0 μm. Due to the durable value of the original report we deemed it worthwhile to provide a similar atlas for this new spectral region.

As an historical note the calculations for the first report were done in 1983 on a DEC PDP-11/40 minicomputer. The computer program used at the time was a version of a HITRAN-like code that was written by one of the current authors (Trusty) while a graduate student at Ohio State University. He had brought the code with him to NRL where S. Hanley and K. Haught each added significant improvements to it as it became an integral part of the section operation.

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Today we do the calculations on a PC, using a commercial product[2], which is a version of the AFGL(AirForce Geophysical Laboratory, now Phillips Laboratory) FASCODE[3]. Thus, this report, unlike the original, is not based on an NRL-produced calculational capability. It is presented, instead, as a result of NRL's continued interest in high-resolution propagation issues. Except for the spectal region, the output product here is essentially the same as that of the first report; the primary improvement is probably in the accuracy of the more recent AFGL Absorption Atlas[4] data, the basis of all HITRAN-like codes.

Note that most of the atmospheric absorption in this spectral region comes from water vapor, and therefore, the actual transmittance of a particular laser line can vary significantly with a change in humidity. By necessity, the plots in the report give results for only one value of humidity. Thus, they are only to provide a quick check on applicability to propagation through the atmosphere to determine if further study is required.

For consistancy with the earlier report, we have chosen the AFGL Mid-Latitude Summer model[5] for the atmospheric conditions. At sea level, which these current calculations represent, this gives a temperature of 21 °C and a water vapor pressure of 14 torr. While the earlier report considered only molecular absorption, here, primarily because of the larger scattering contribution at these shorter wavelengths, we have included aerosol scattering. We used the Maritime 23Km-Visibility aerosol model in the calculations. The low-resolution LOWTRAN[6] plot in Fig. 1 shows the resultant total transmittance for the entire spectral region as well as the transmittance for the aerosol scattering contribution.

THE COMPUTED HIGH-RESOLUTION SPECTRA

The high-resolution plots are given in the Appendix. Each page shows a plot of the extinction coefficient of the atmosphere, for the conditions given above, over the 40-cm^{-1} spectral region noted by the X-axis. Because each plot does show a labeled X-axis noting the spectral region, figure numbers and figure captions seemed redundant and are not included.

REFERENCES

1. D.H. Leslie, and P.S. Lebow, "Computed Survey Spectra of 2-5μ Atmospheric Absorption", NRL Memorandum Report 5168, August 31, 1983

2. ONTAR Corporation, PC-LnTRAN, Version 2.1, 129 University Rd., Brookline, MA 02146

3. S.A. Clough, F.X. Kneizys, L.S. Rothman, W.O. Gallery, "Atmospheric Spectral Transmittance and Radiance: FASCOD1B," SPIE 277, Atmospheric Transmission (1981)

4. L.S. Rothman, et al.,"The HITRAN database: 1986 edition", Applied Optics, 26, No. 19, p 4058, 1 Oct 1987

5. G.P. Anderson, S.A. Clough, F.X. Kneizys, J.H. Chetwynd, E.P. Shettle, "AFGL Atmospheric Constituent Profiles" (0-120 km), ERP Report No. 954, AFGL-TR-86-0110, 15 May 1986

6. ONTAR Corporation, PC-TRAN, 129 University Rd., Brookline, MA 02146

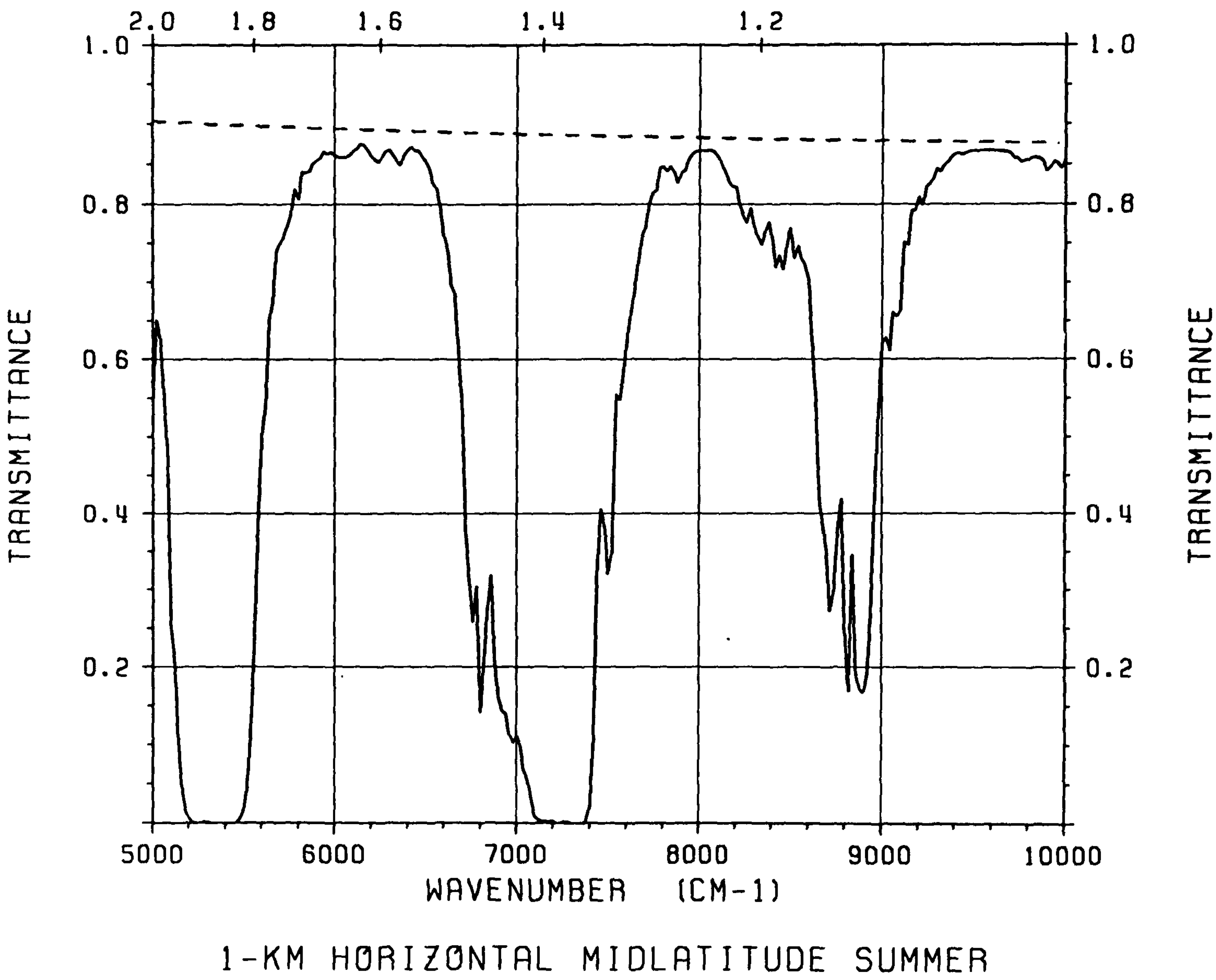
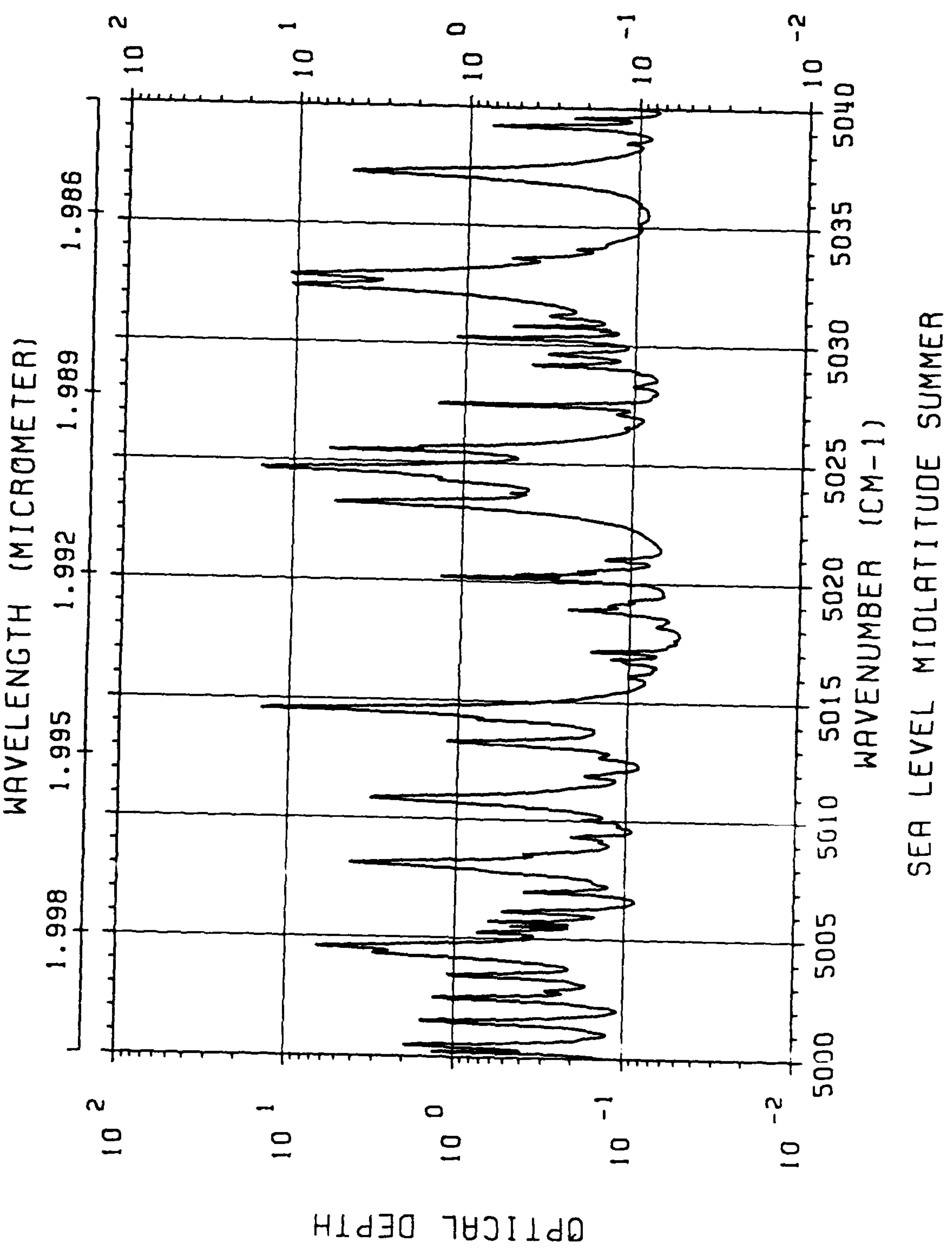


Figure 1. Low-resolution plot of transmittance between 1.0 and 2.0 μm

APPENDIX

THE COMPUTED HIGH-RESOLUTION SPECTRA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1.995
1.992
1.989
1.986
WAVENUMBER (CM-1)
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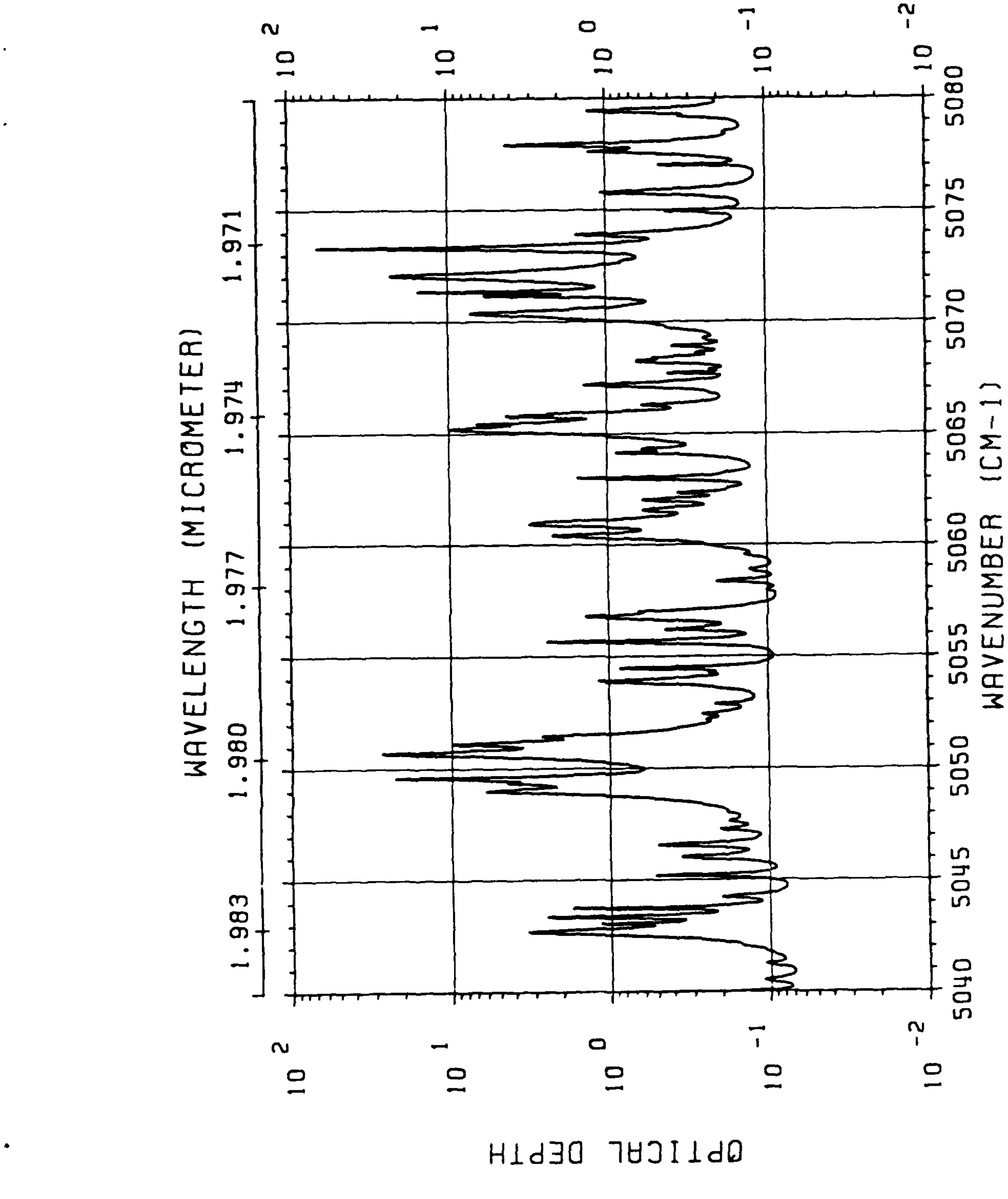
5005
5010
5015
5020
5025
5030
5035
5040
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}



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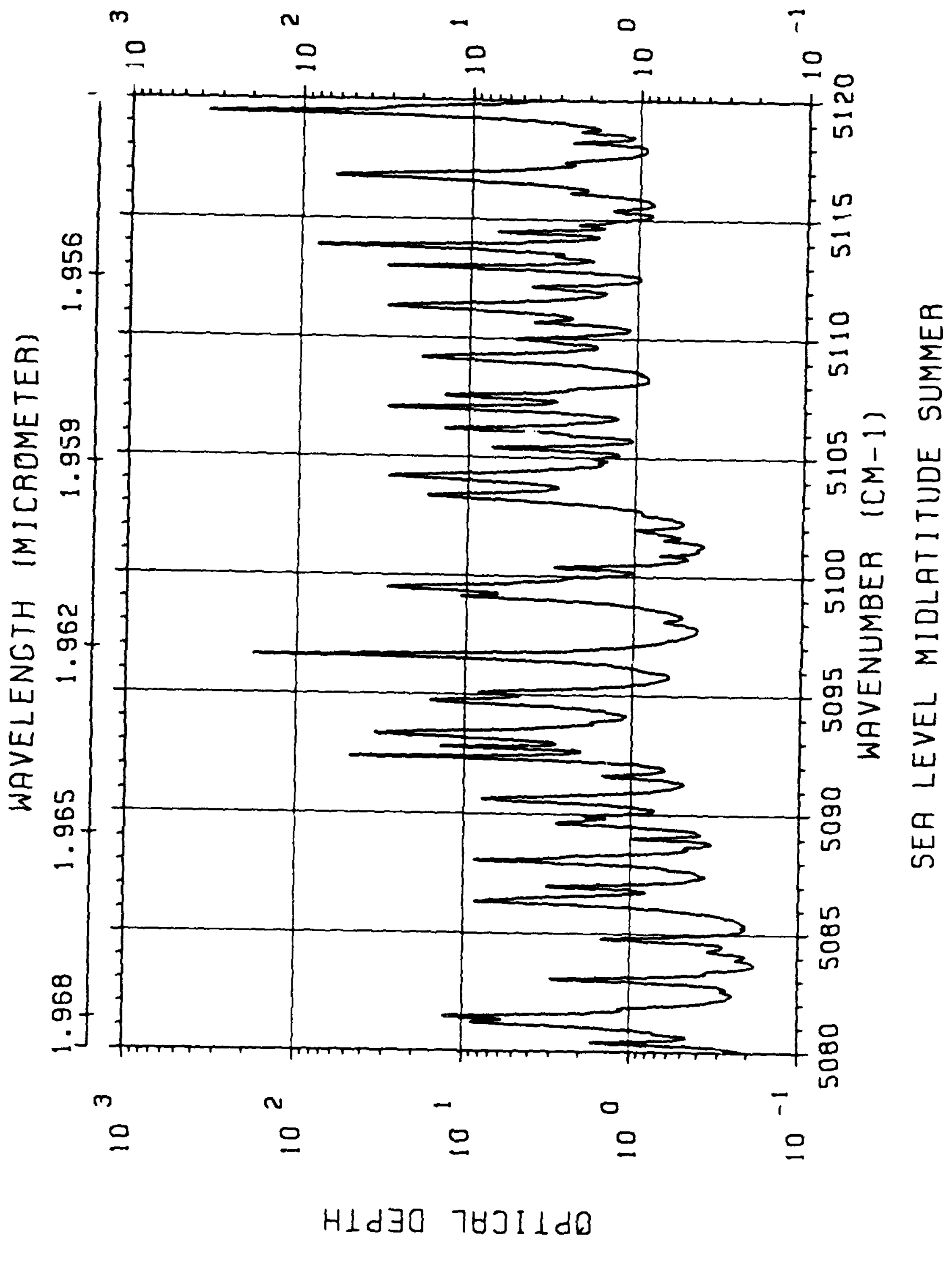
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10 2
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10 -1
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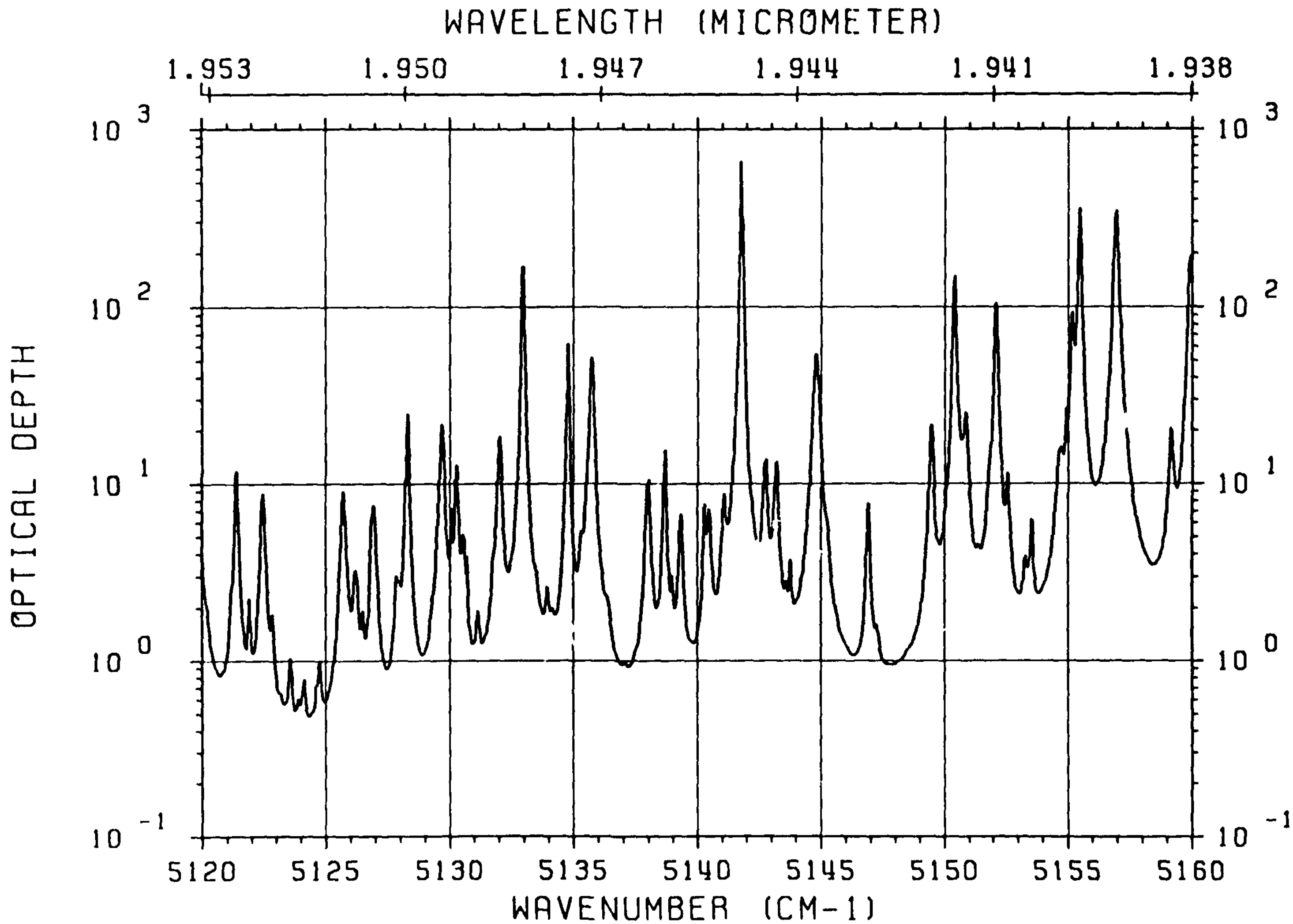
SEA LEVEL MIDLATITUDE SUMMER



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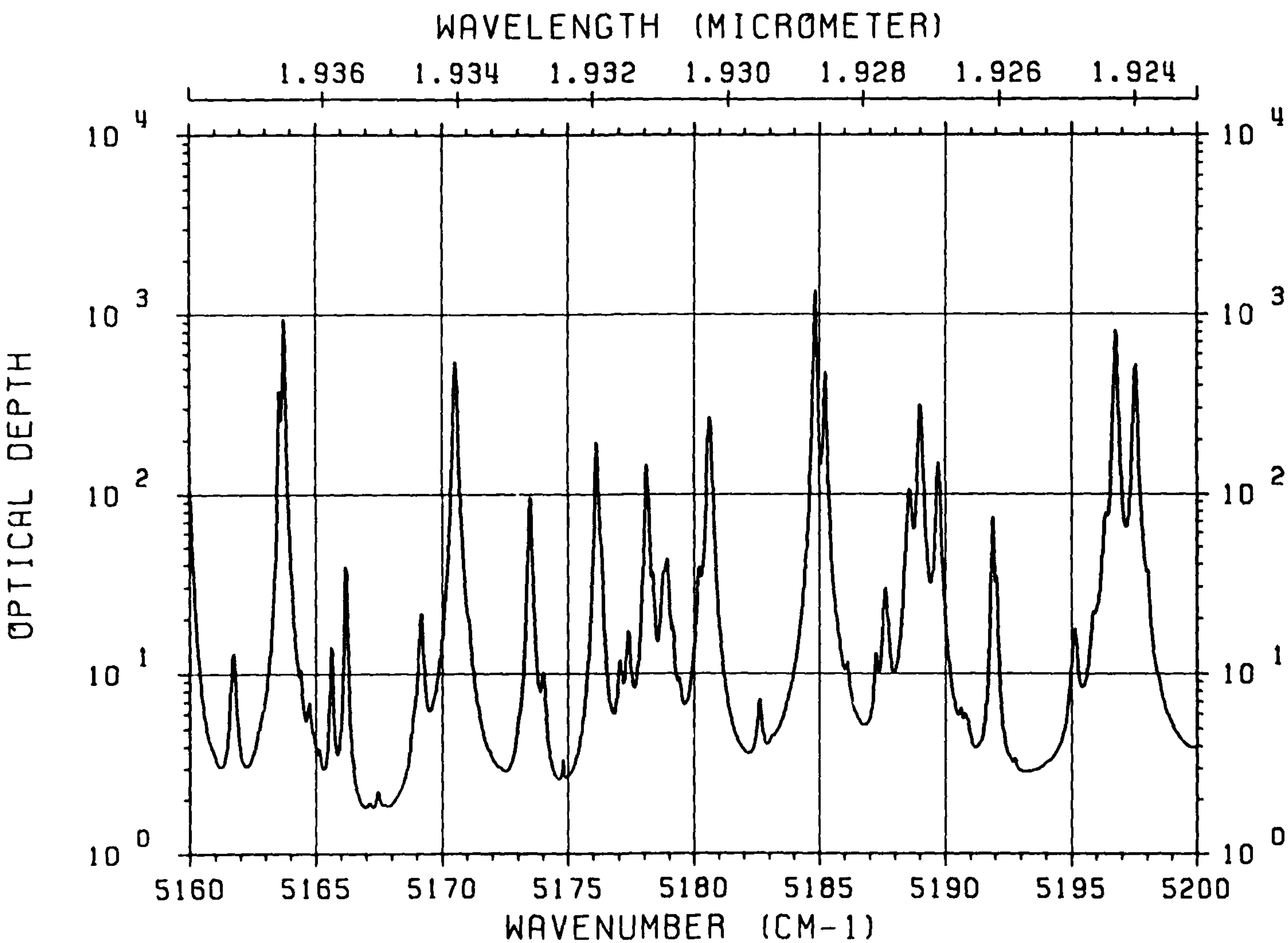

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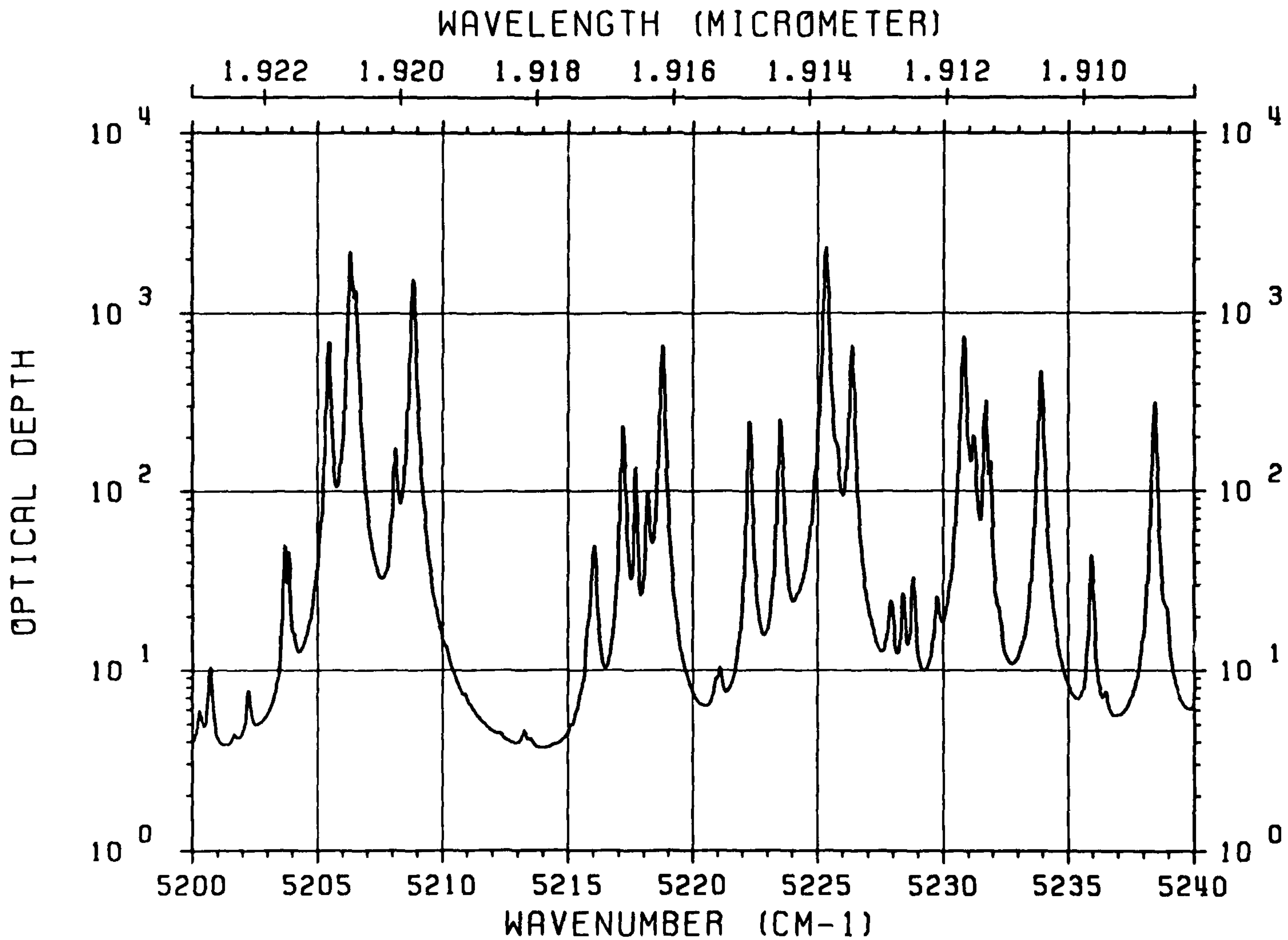

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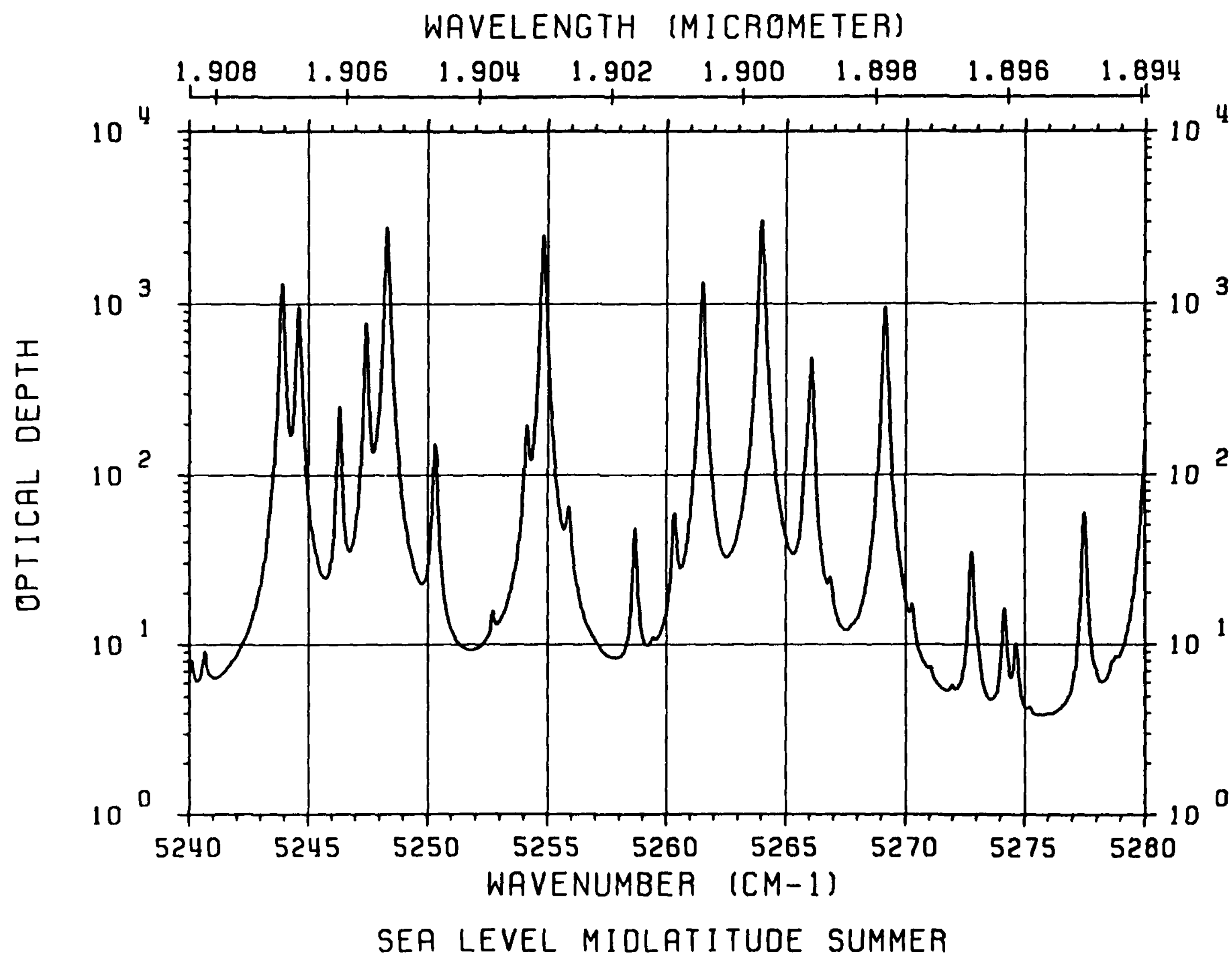
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1.894
OPTICAL DEPTH
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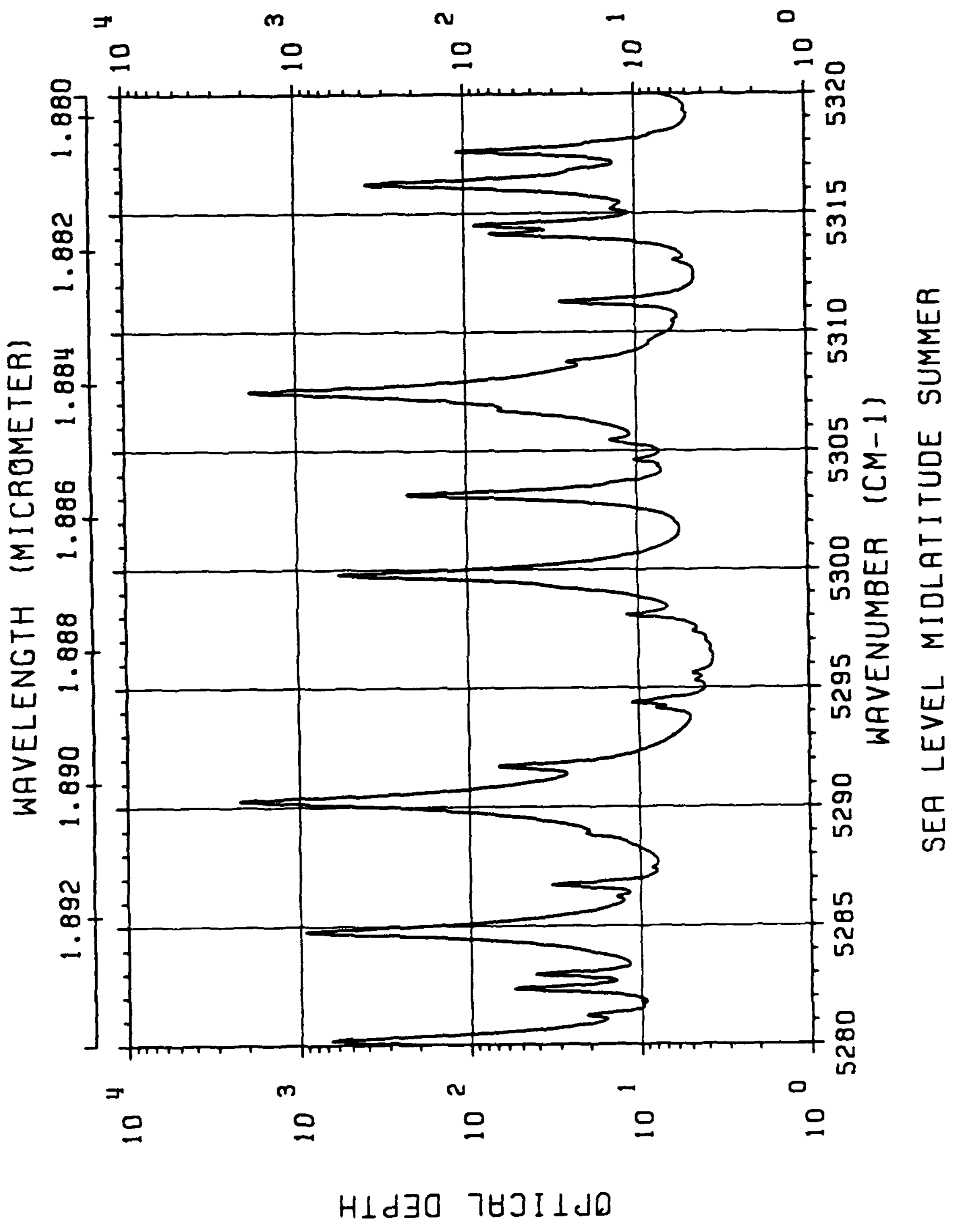
10^{3}
10^{2}
10^{1}
10^{0}
5240
5245
5250
5255
5260
5265
5270
5275
5280
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER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10^3
10^2
10^1
10^0
5320
5315
5310
5305
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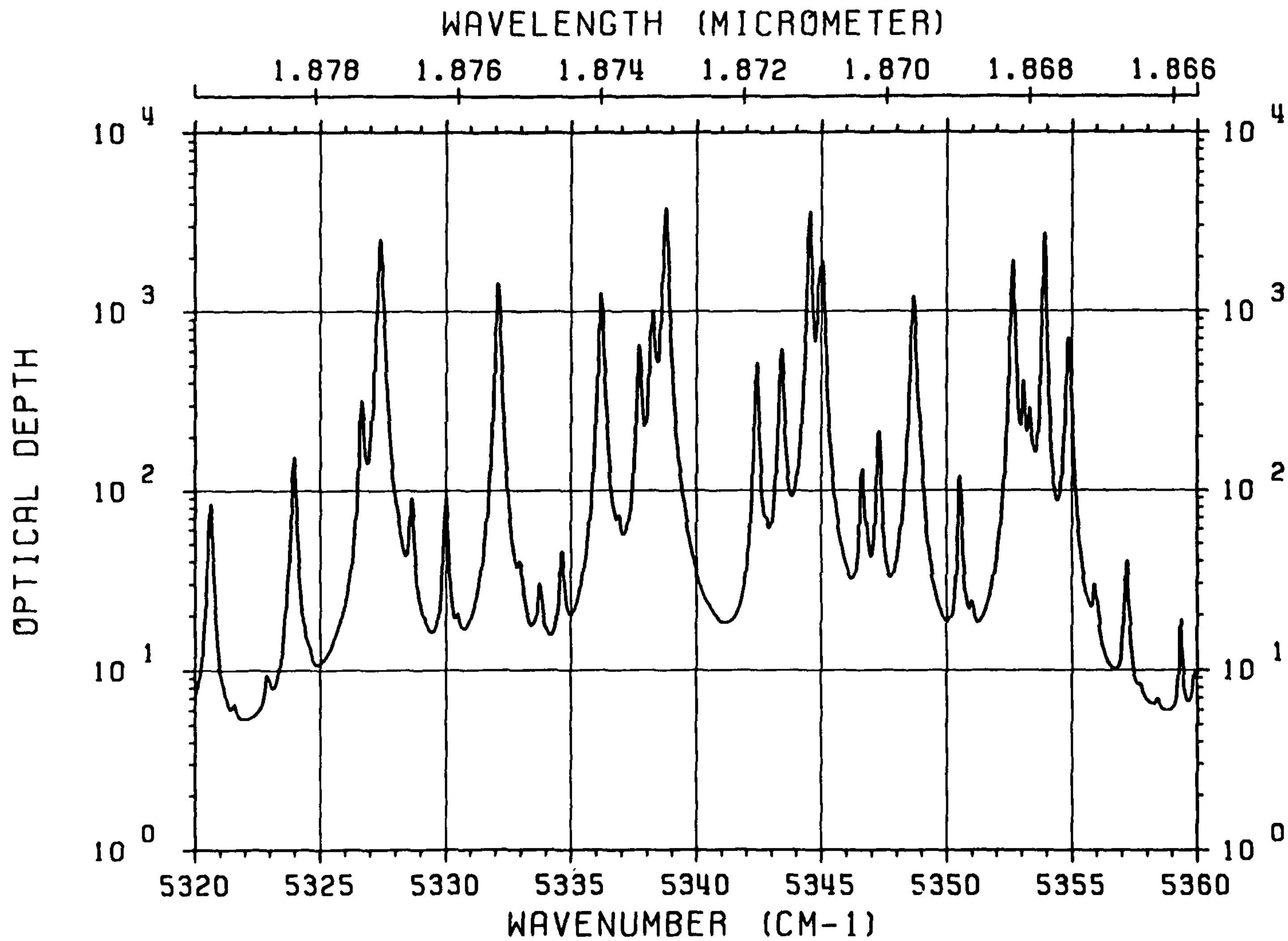
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH



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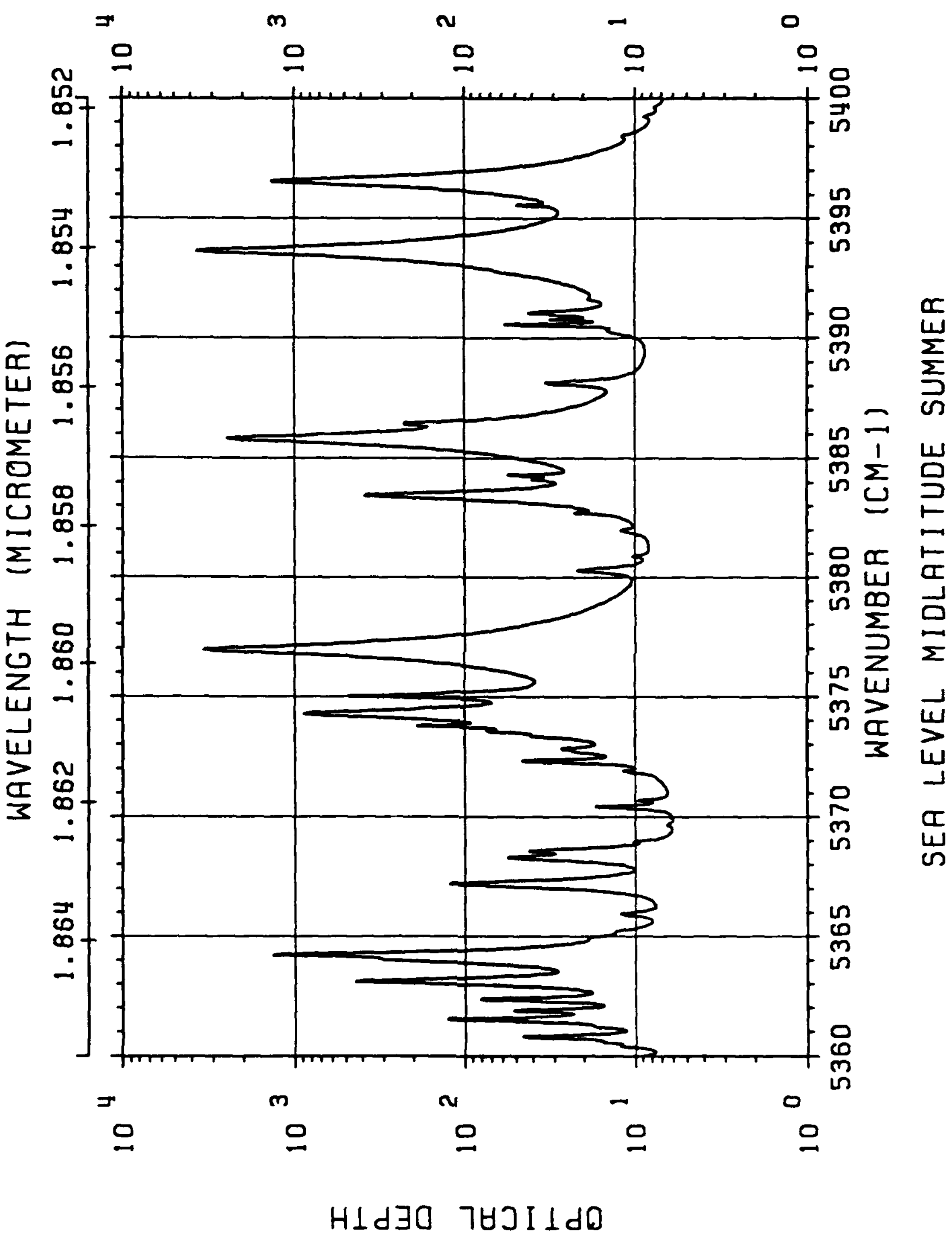
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5375
5380
5385
5390
5395
5400
WAVENUMBER (CM-1)
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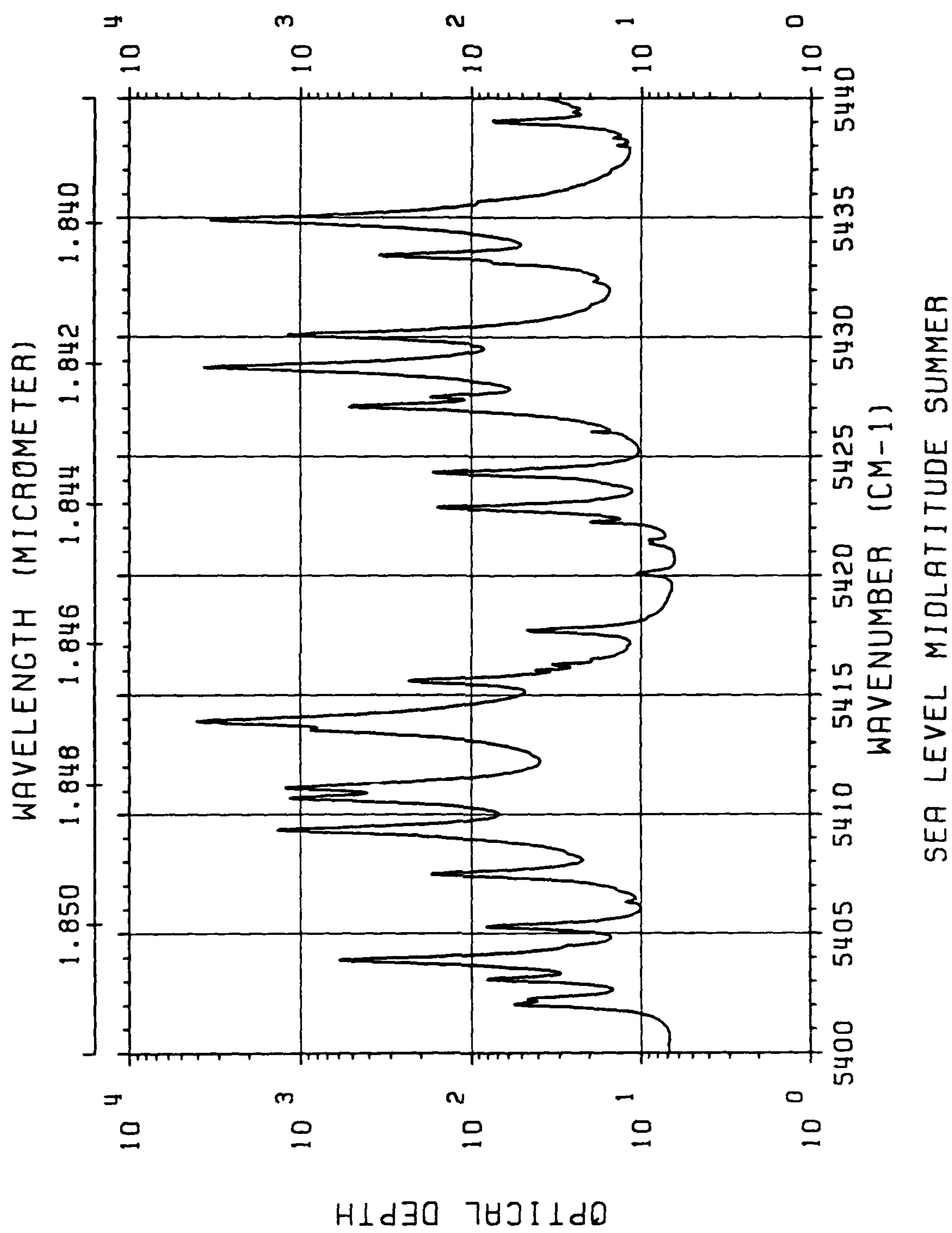
10 2
10 3
10 4
OPTICAL DEPTH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5400
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5410
5415
5420
5425
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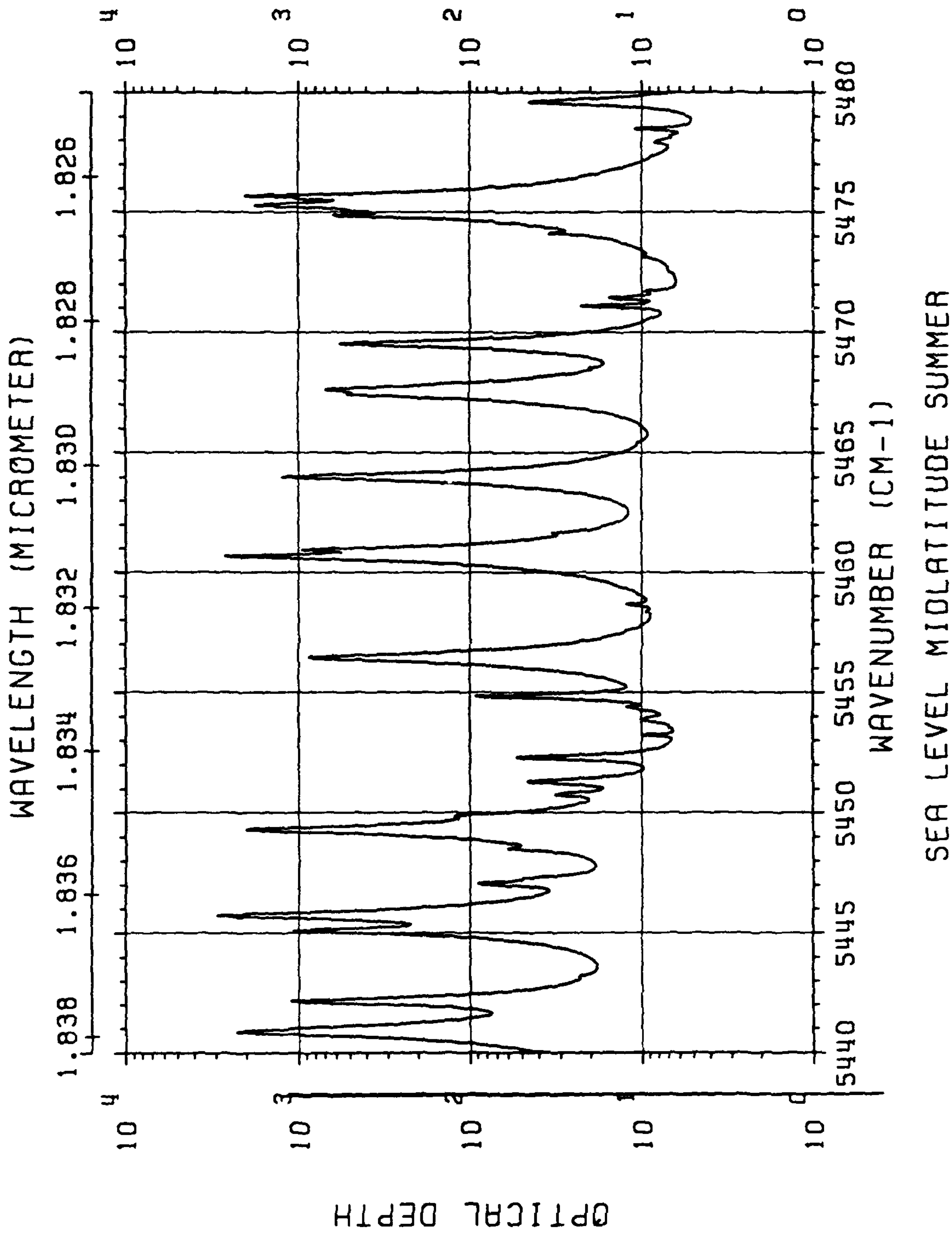
5440
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^0
10^1
10^2
10^3
10^4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1.826
OPTICAL DEPTH
10^0
10^1
10^2
10^3
10^4
5440
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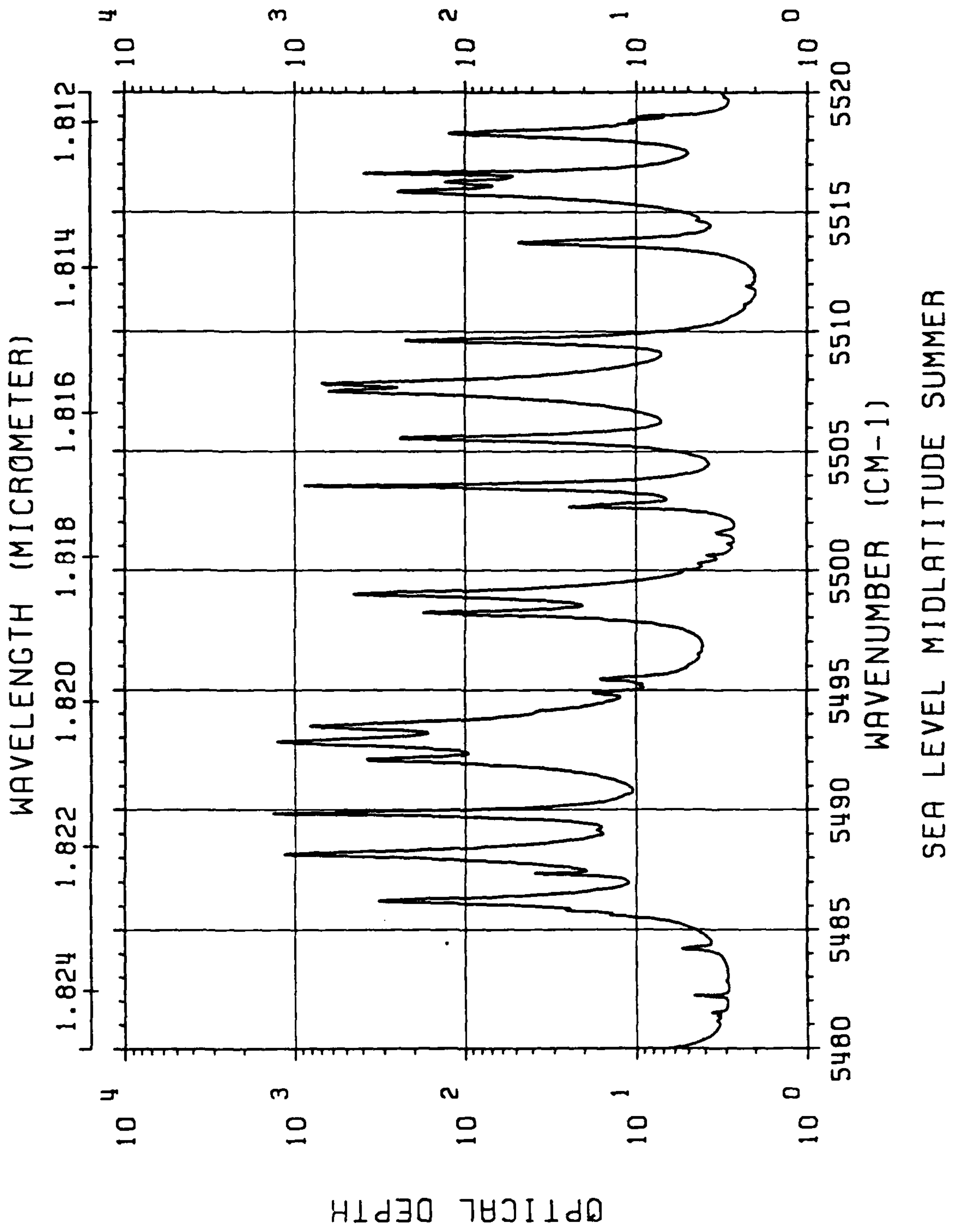
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER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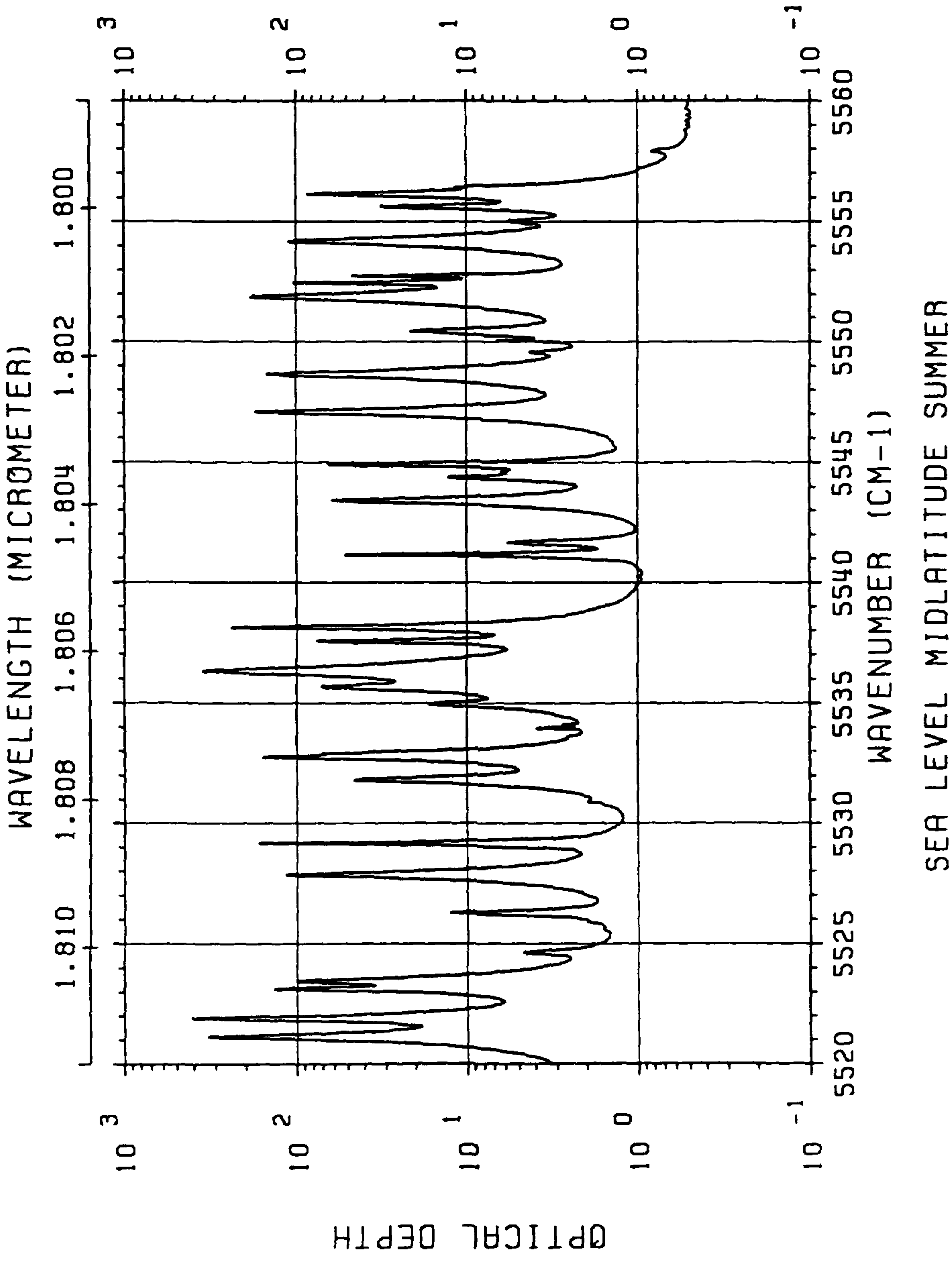
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH



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1.802
1.804
1.806
1.808
1.810
WAVENUMBER (CM-1)
5520
5525
5530
5535
5540
5545
5550
5555
5560
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
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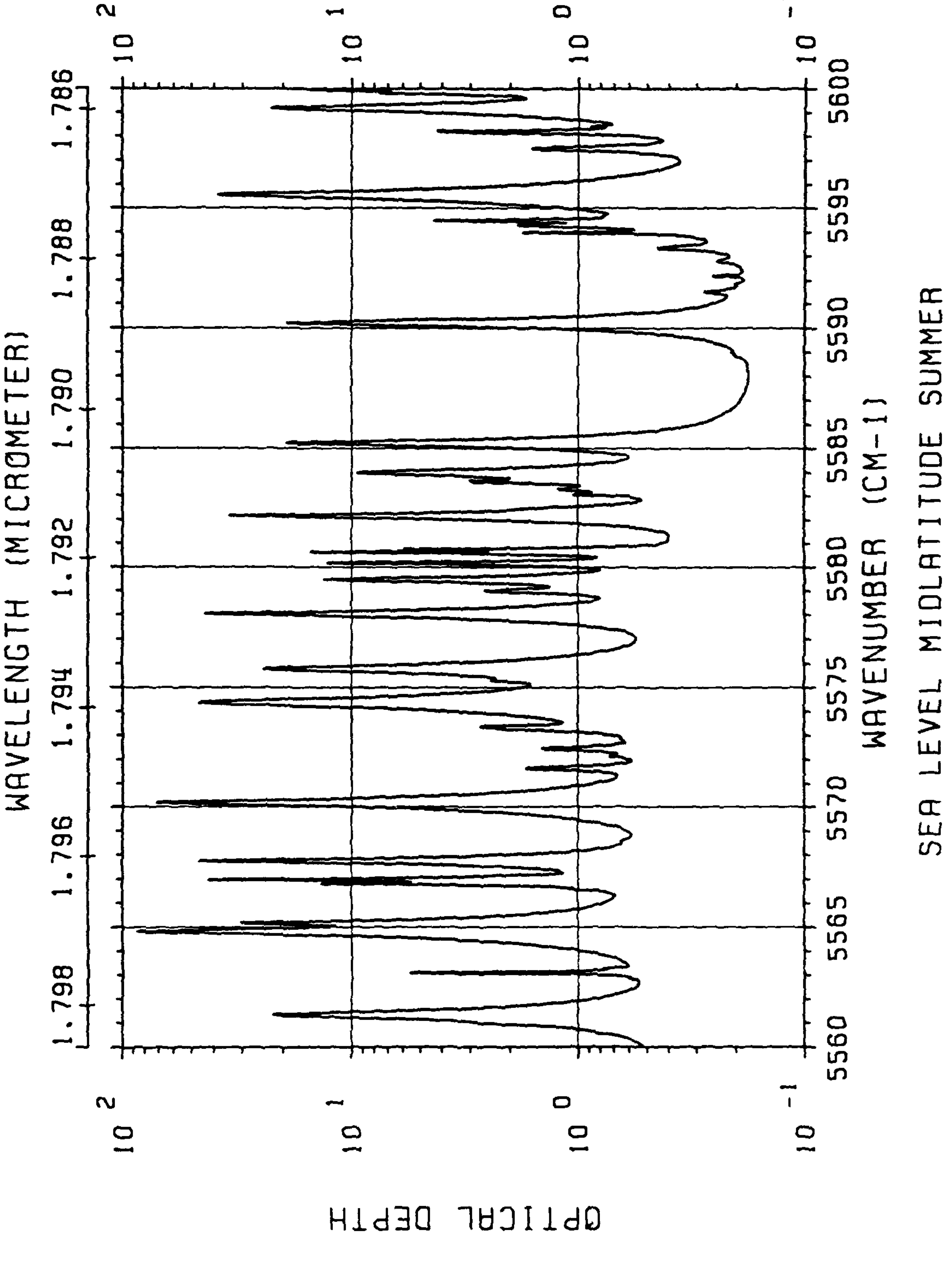
10^{2}
10^{1}
10^{0}
10^{-1}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1.798
WAVENUMBER (CM-1)
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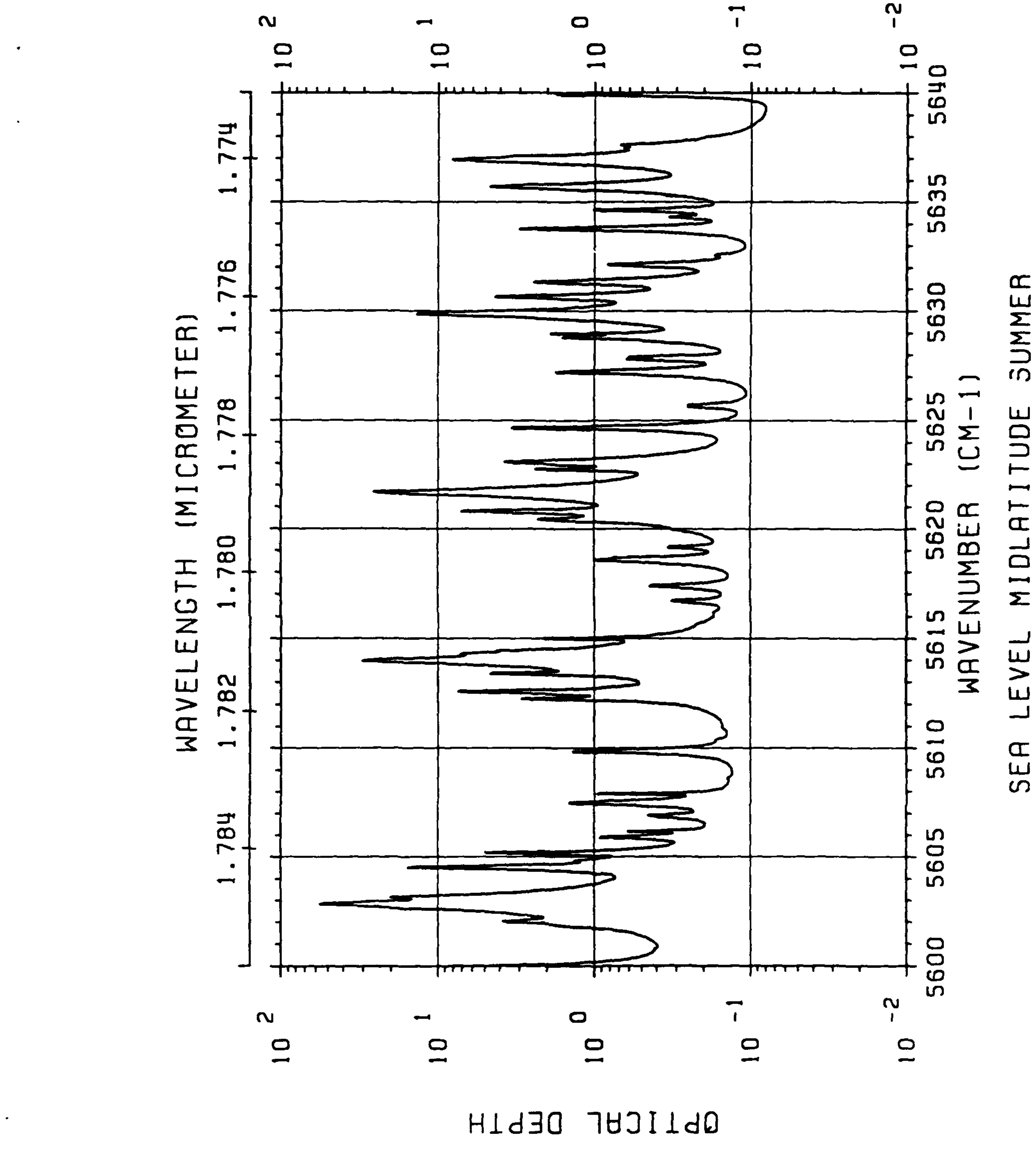
5565
5570
5575
5580
5585
5590
5595
5600
OPTICAL DEPTH
10^{2}
10^{1}
10^{0}
10^{-1}
SEA LEVEL MIDLATITUDE SUMMER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10 -2
OPTICAL DEPTH
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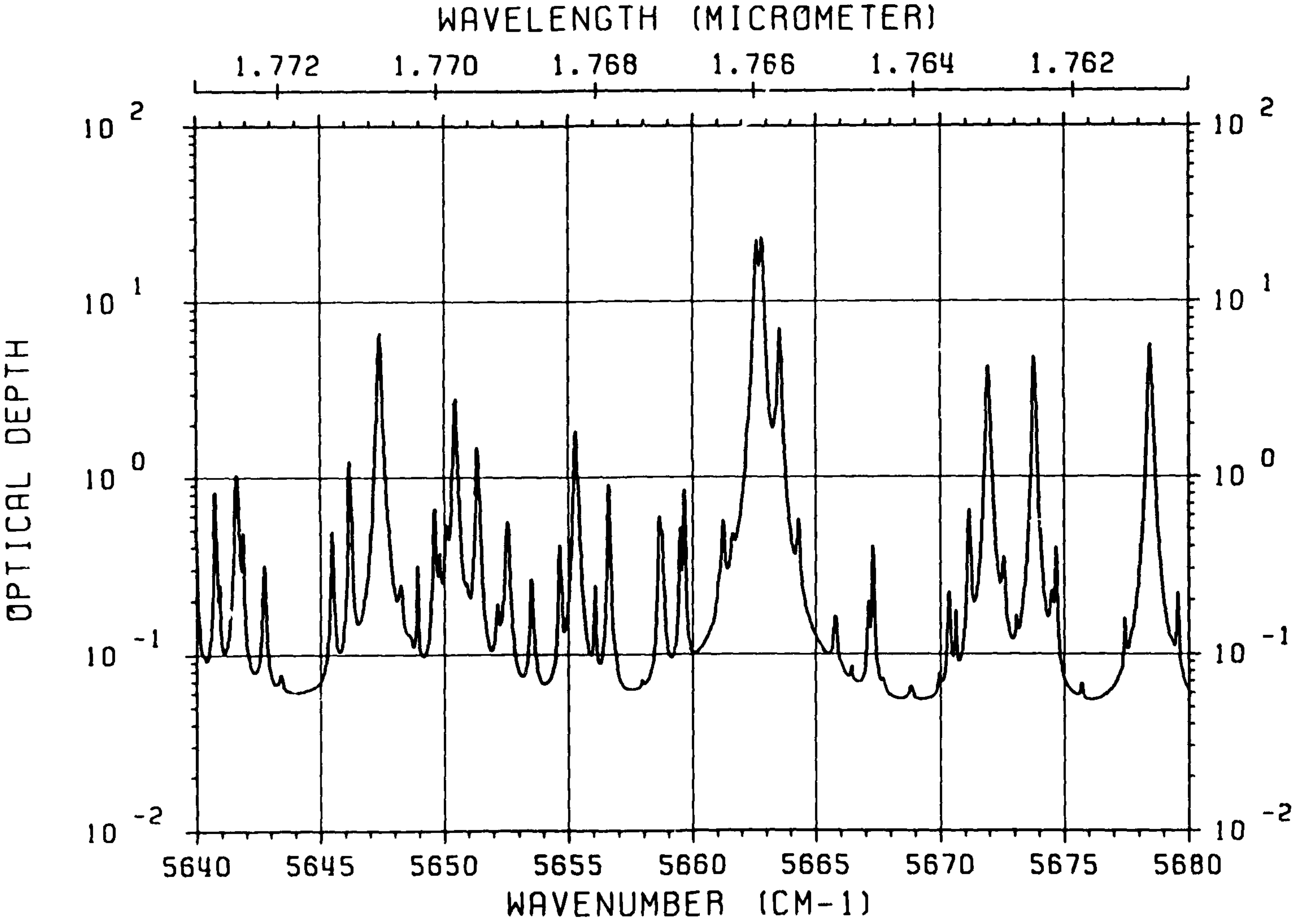
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



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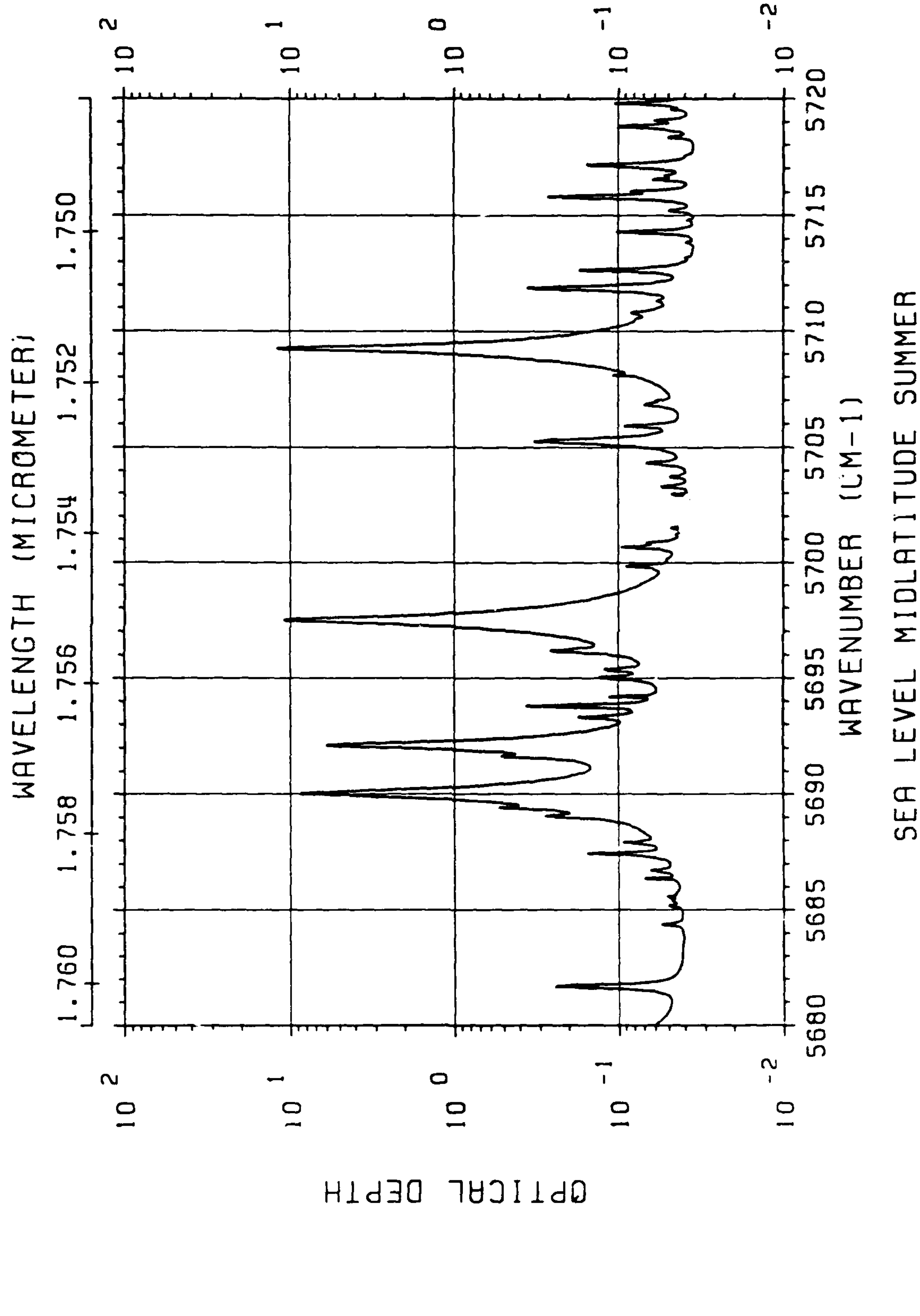
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5685
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5700
5705
5710
5715
5720
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
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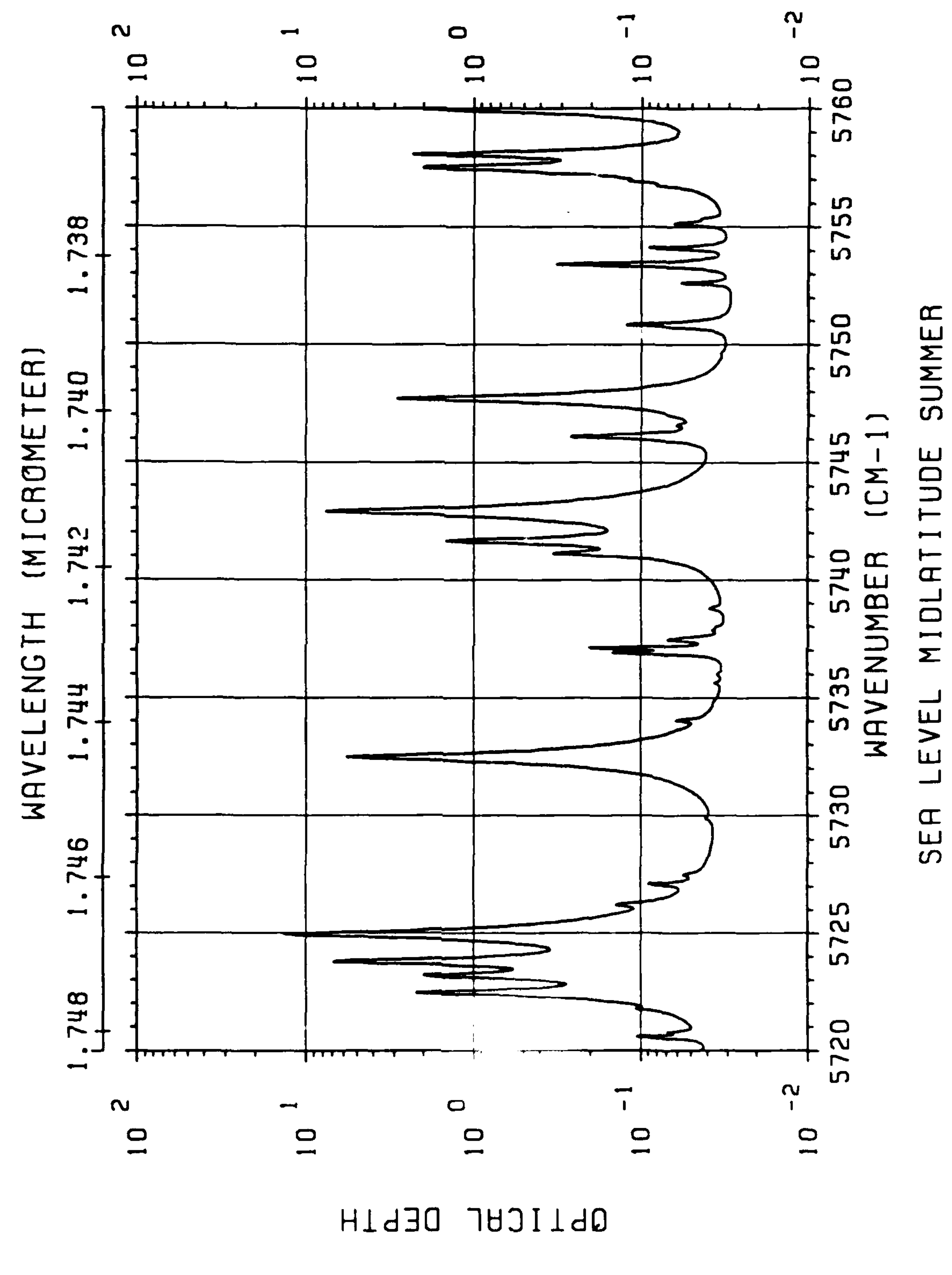
10^{1}
10^{0}
10^{-1}
10^{-2}



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1.744
1.742
1.740
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OPTICAL DEPTH
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
5720
5725
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5740
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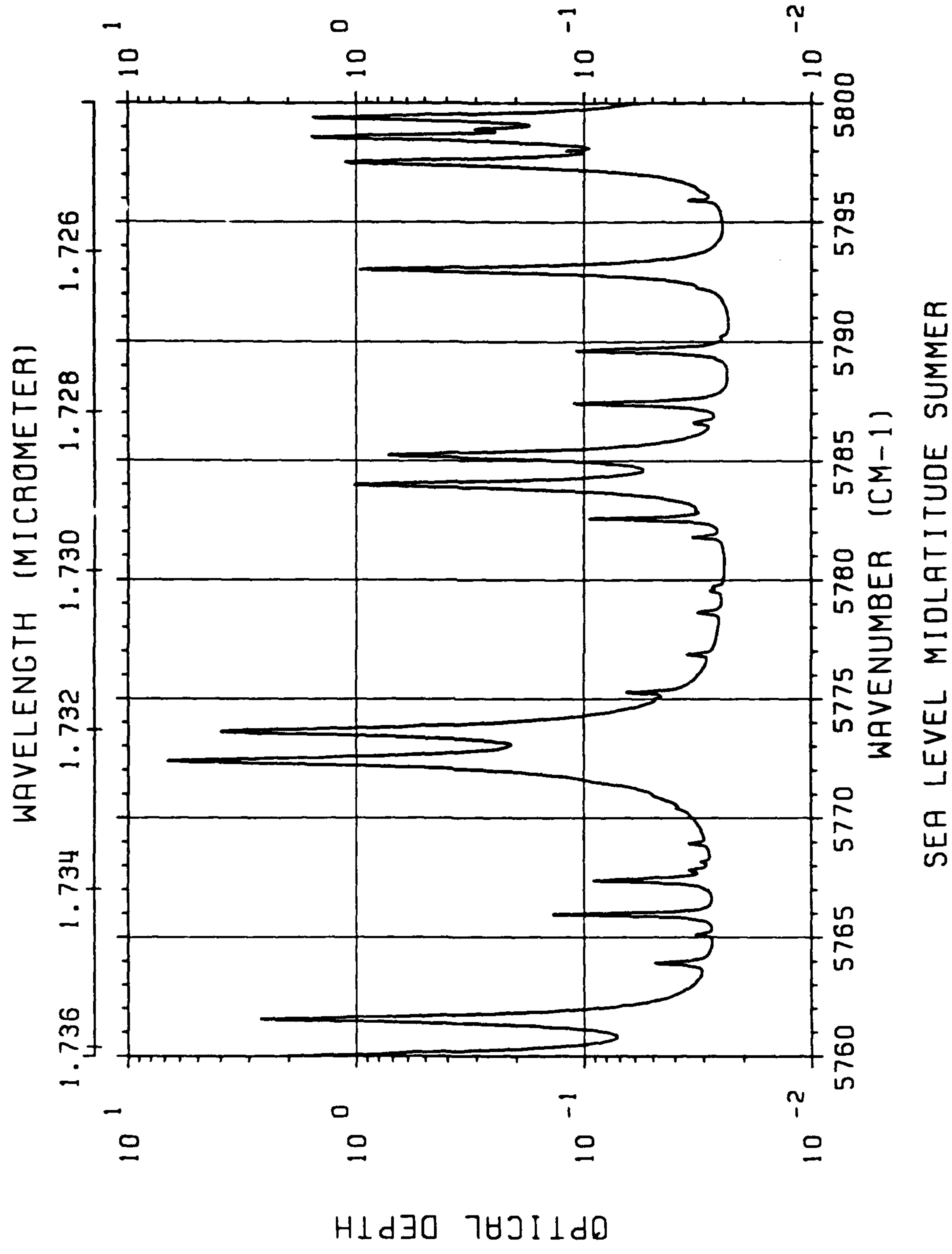
5750
5755
5760
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER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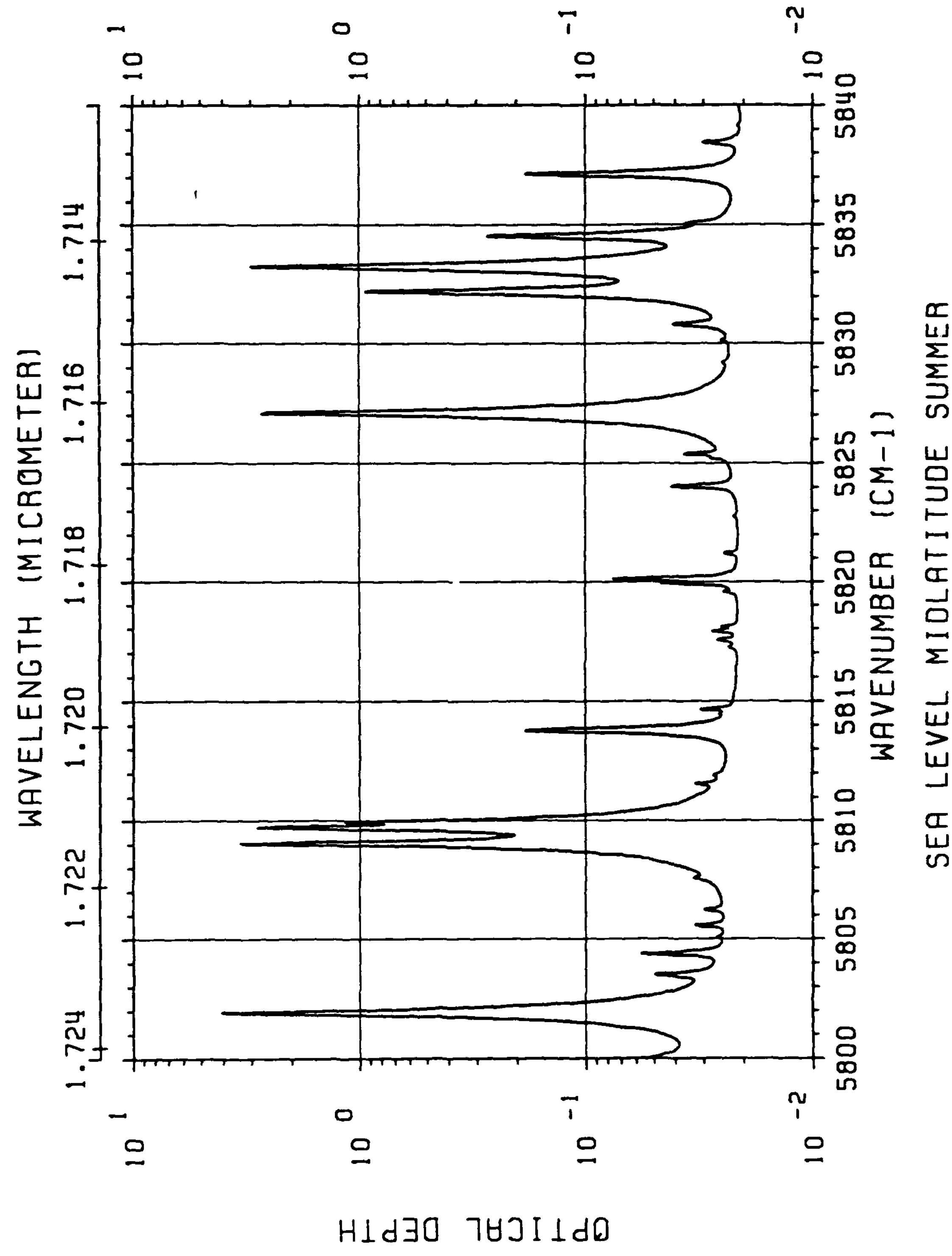
5785
5790
5795
5800
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
10^{1}
10^{0}
10^{-1}
10^{-2}
OPTICAL DEPTH



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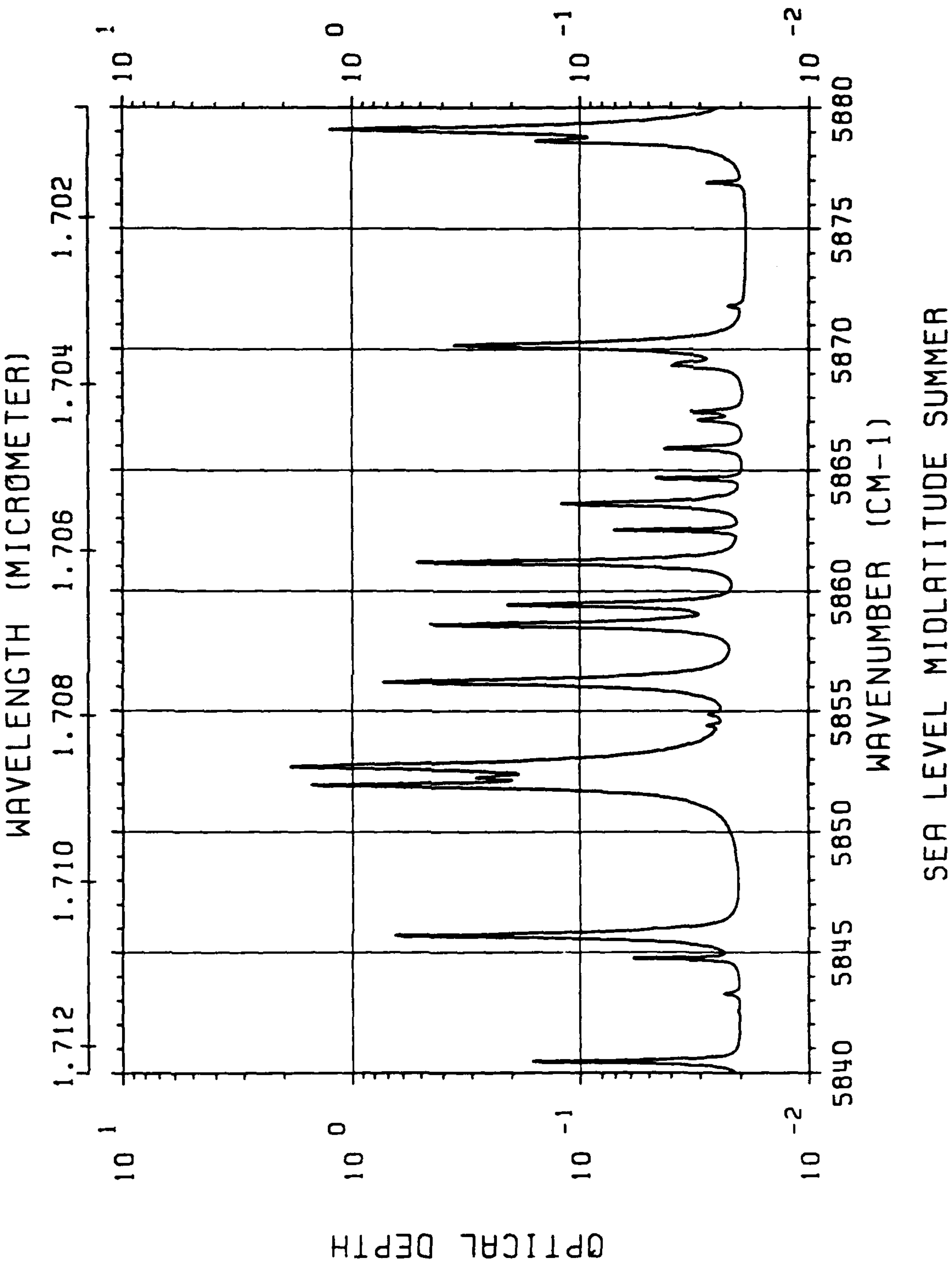
10^{0}
10^{-1}
10^{-2}
5800
5805
5810
5815
5820
5825
5830
5835
5840
OPTICAL DEPTH
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER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10^{1}
10^{0}
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10^{-2}
5880
5875
5870
5865
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5855
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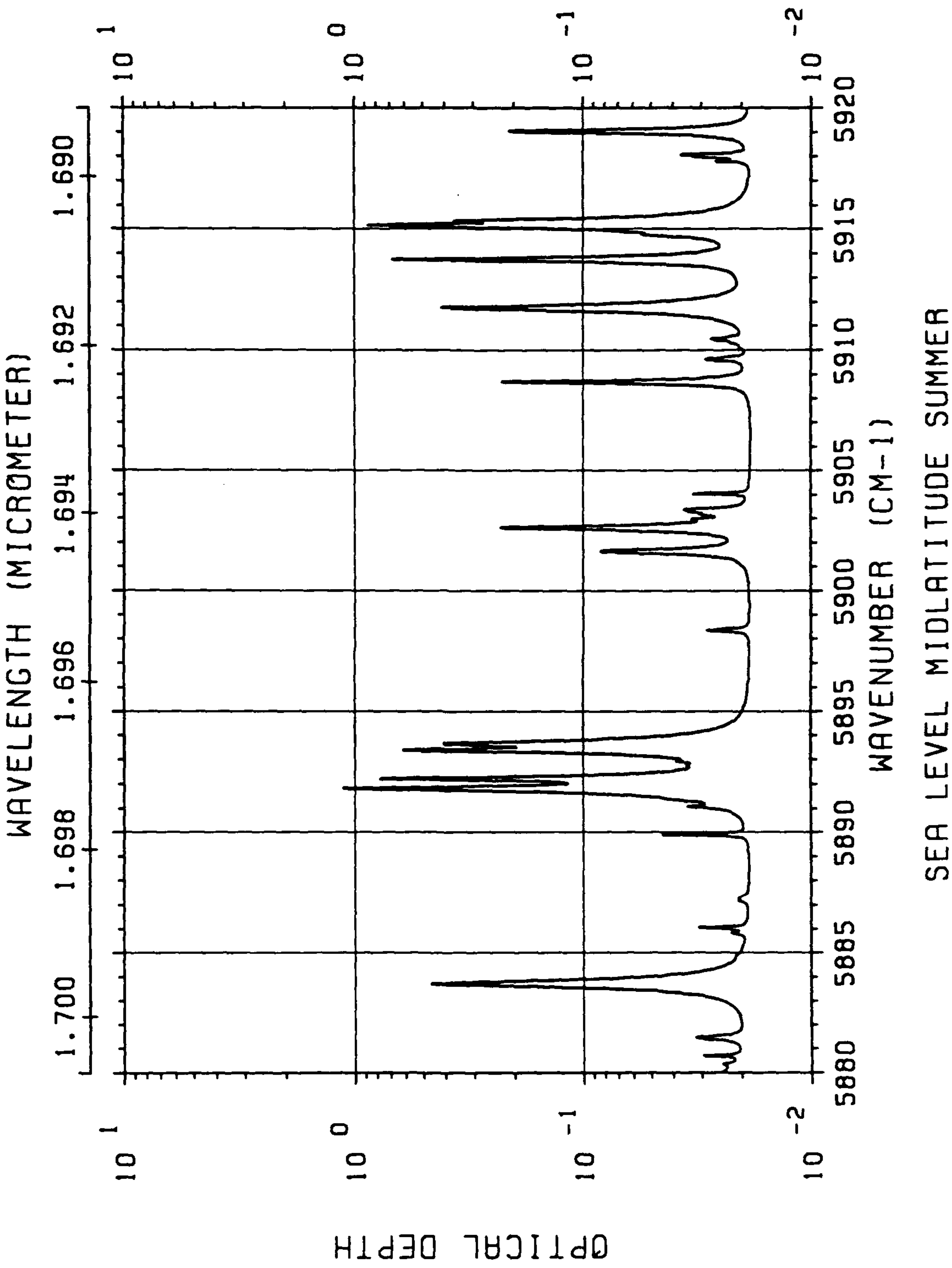
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH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5890
5895
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5920
OPTICAL DEPTH
10^1
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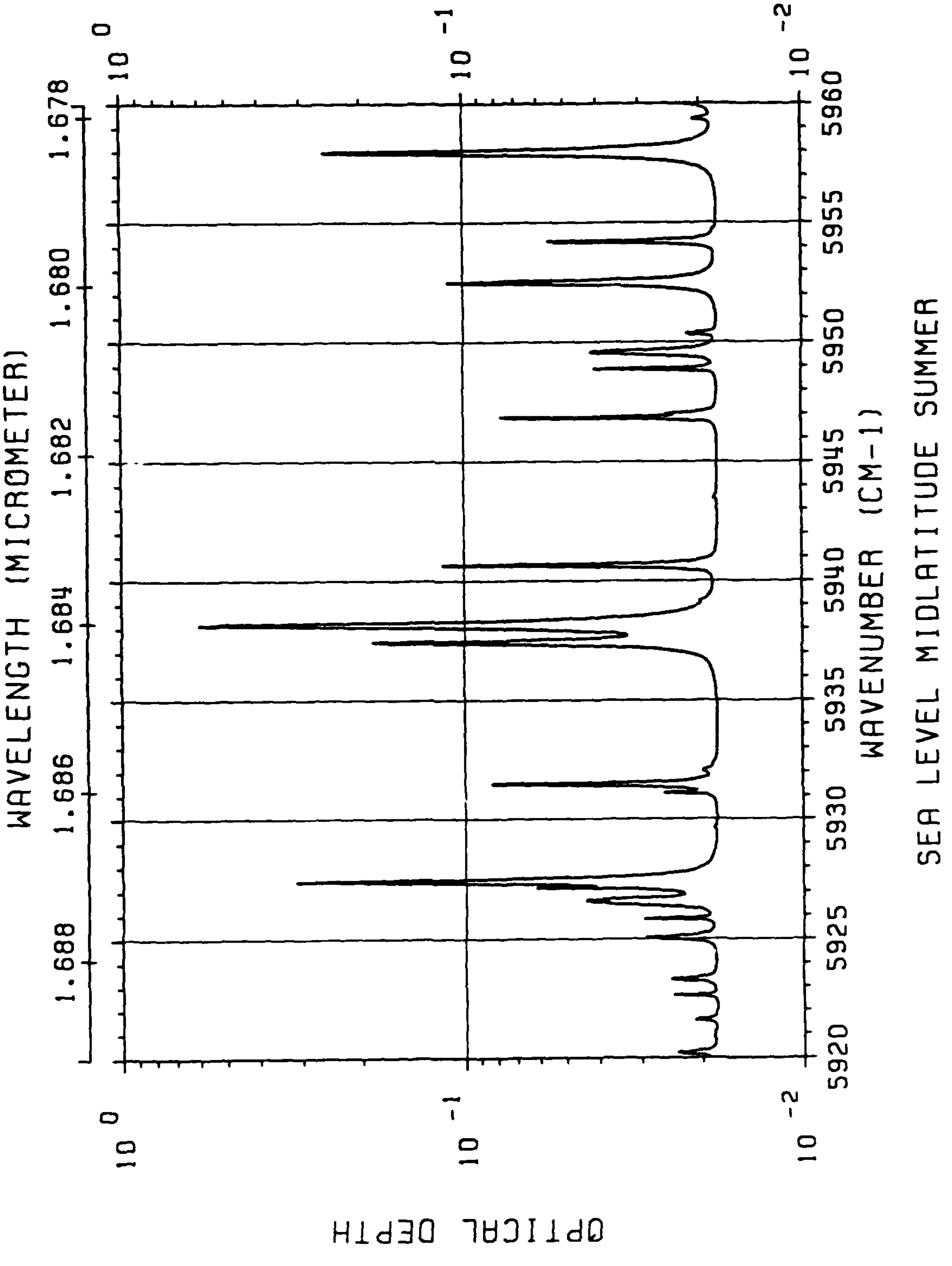
10^-1
10^-2
SEA LEVEL MIDLATITUDE SUMMER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OPTICAL DEPTH
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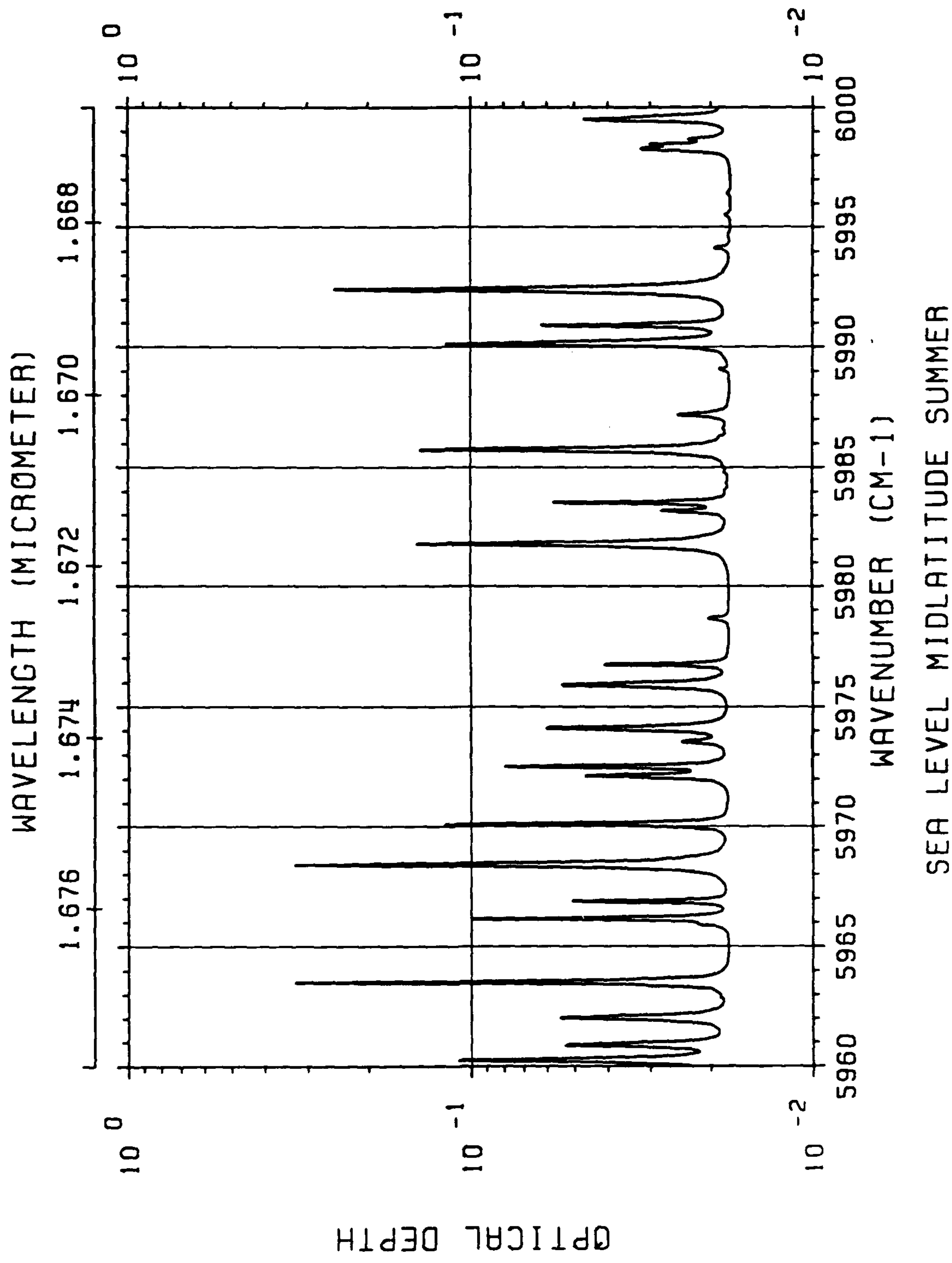
10^-1
10^-2
SEA LEVEL MIDLATITUDE SUMMER



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1.676
10^{0}
10^{-1}
10^{-2}
OPTICAL DEPTH
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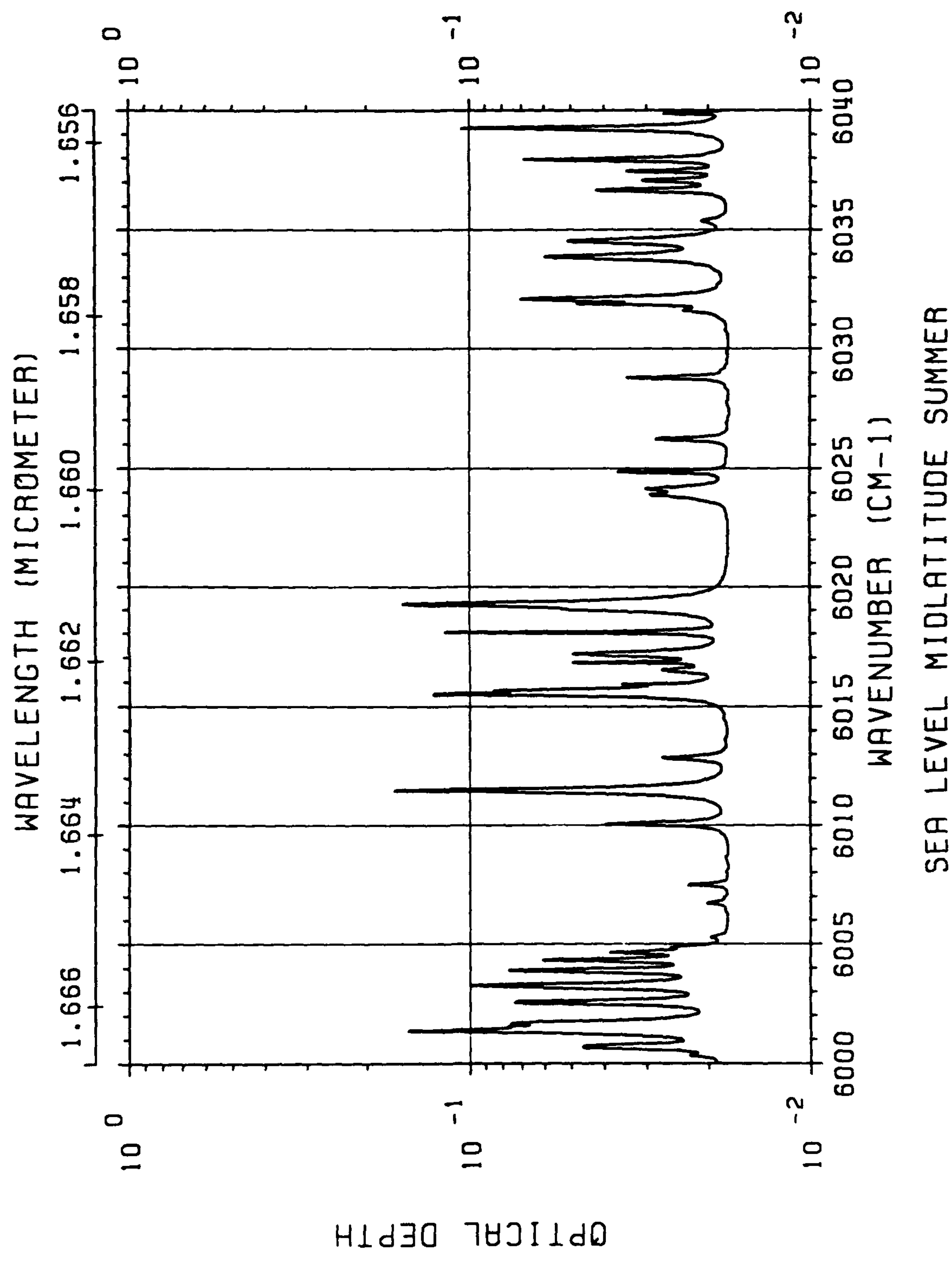
6000
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



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1.666
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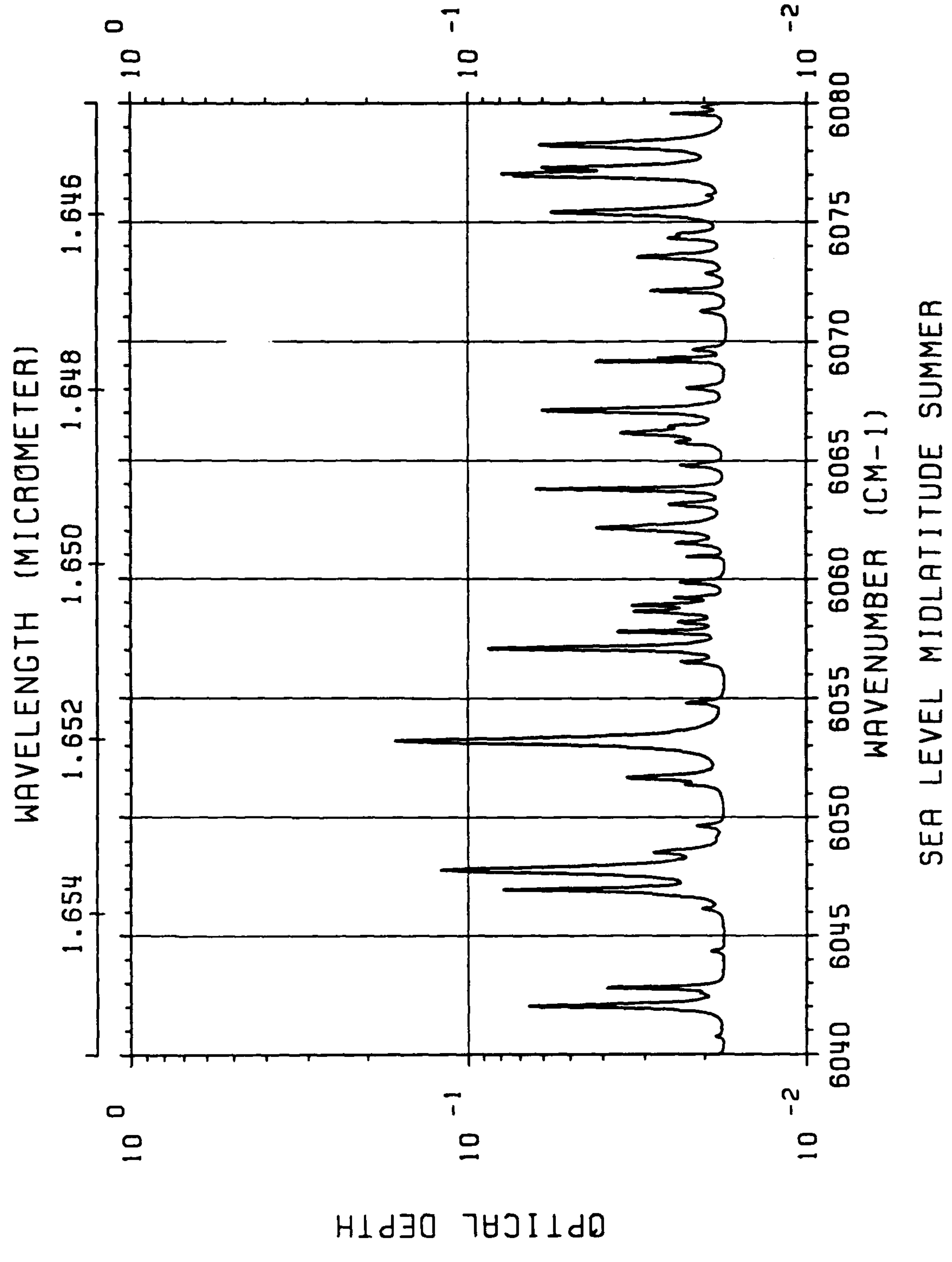
6020
6015
6010
6005
6000
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
10^0
10^-1
10^-2
OPTICAL DEPTH



WAVELENGTH (MICRØMETER)
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10^-1
10^-2
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6045
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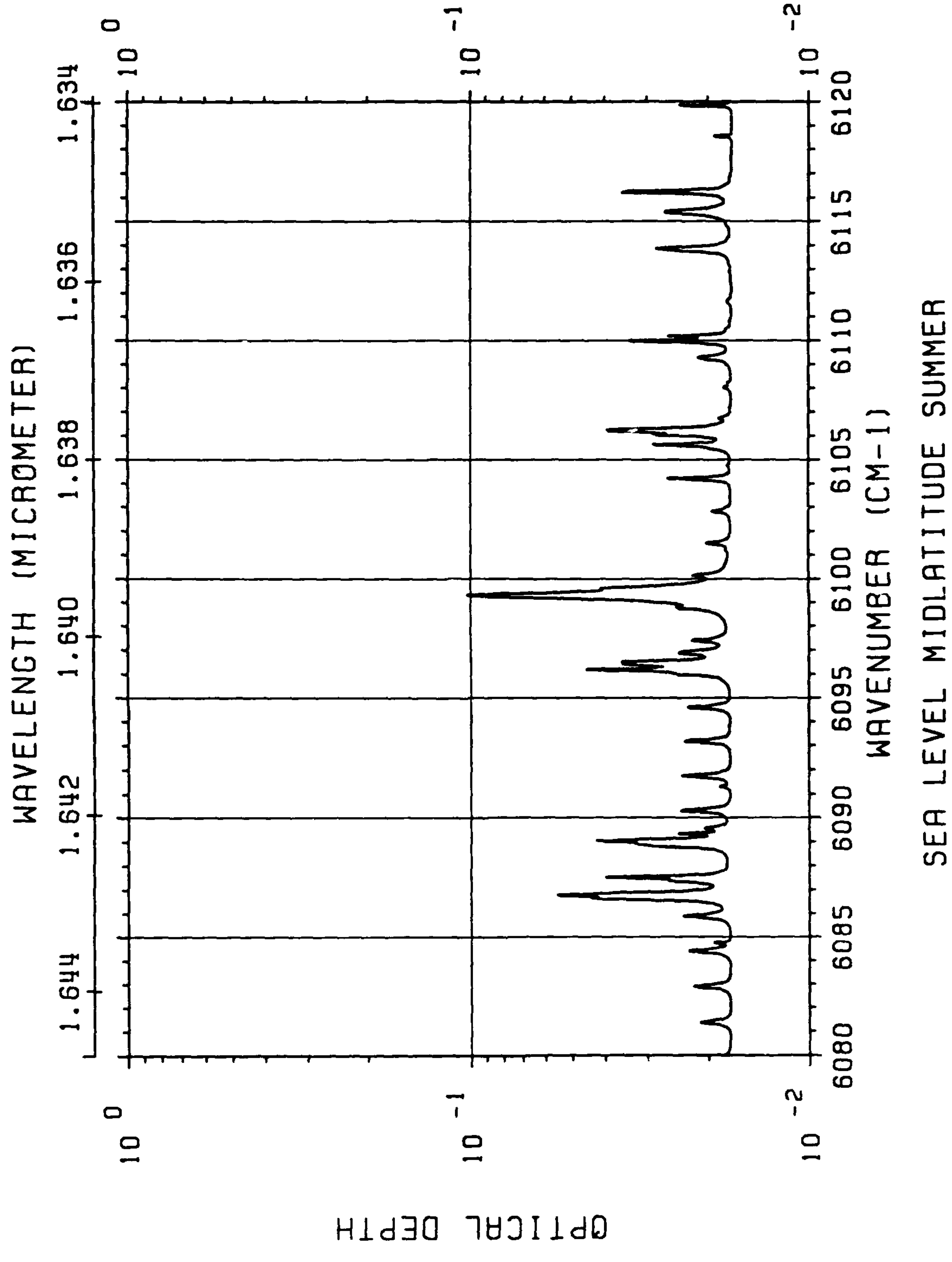
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH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6085
6090
6095
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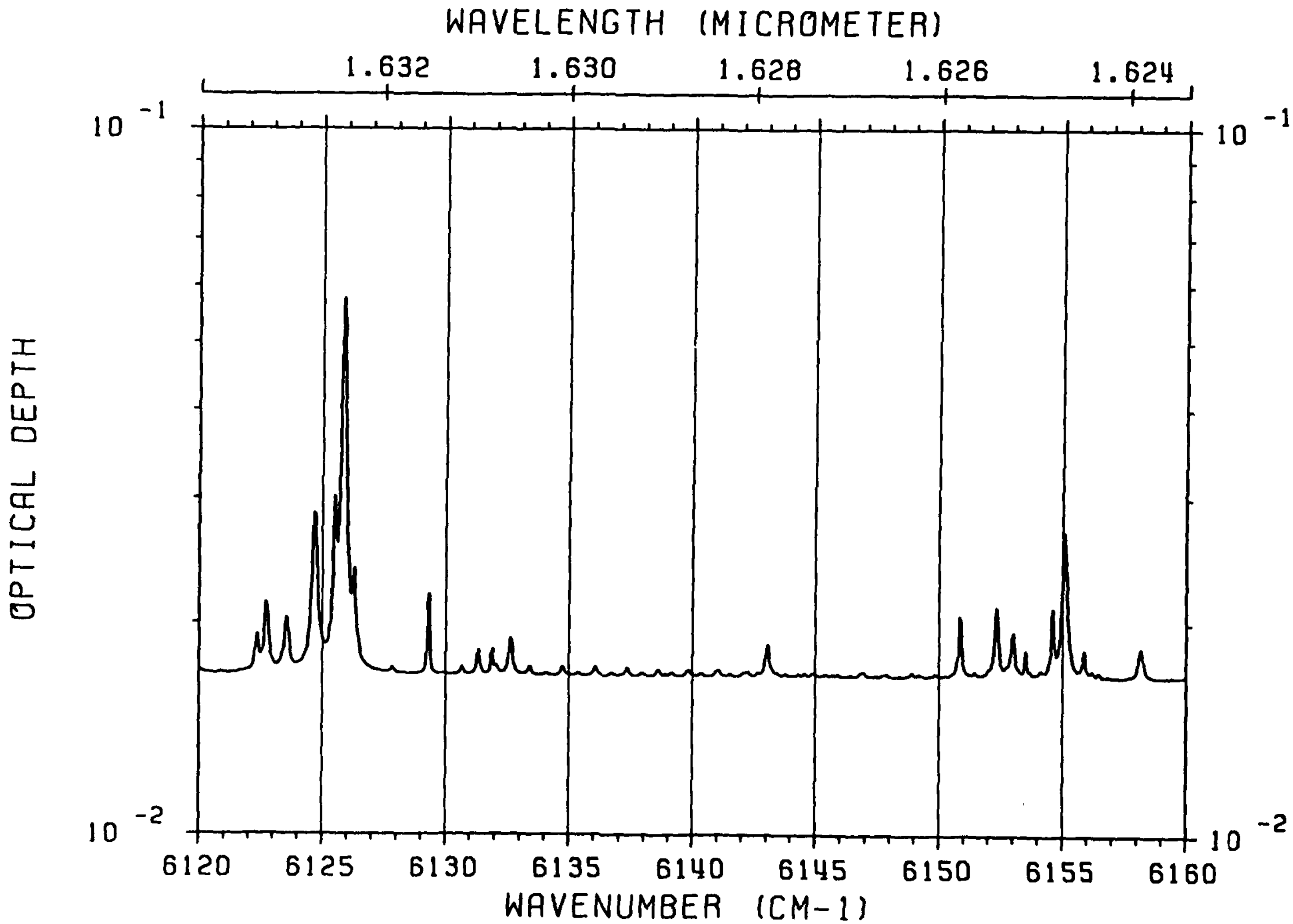
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^0
10^-1
10^-2



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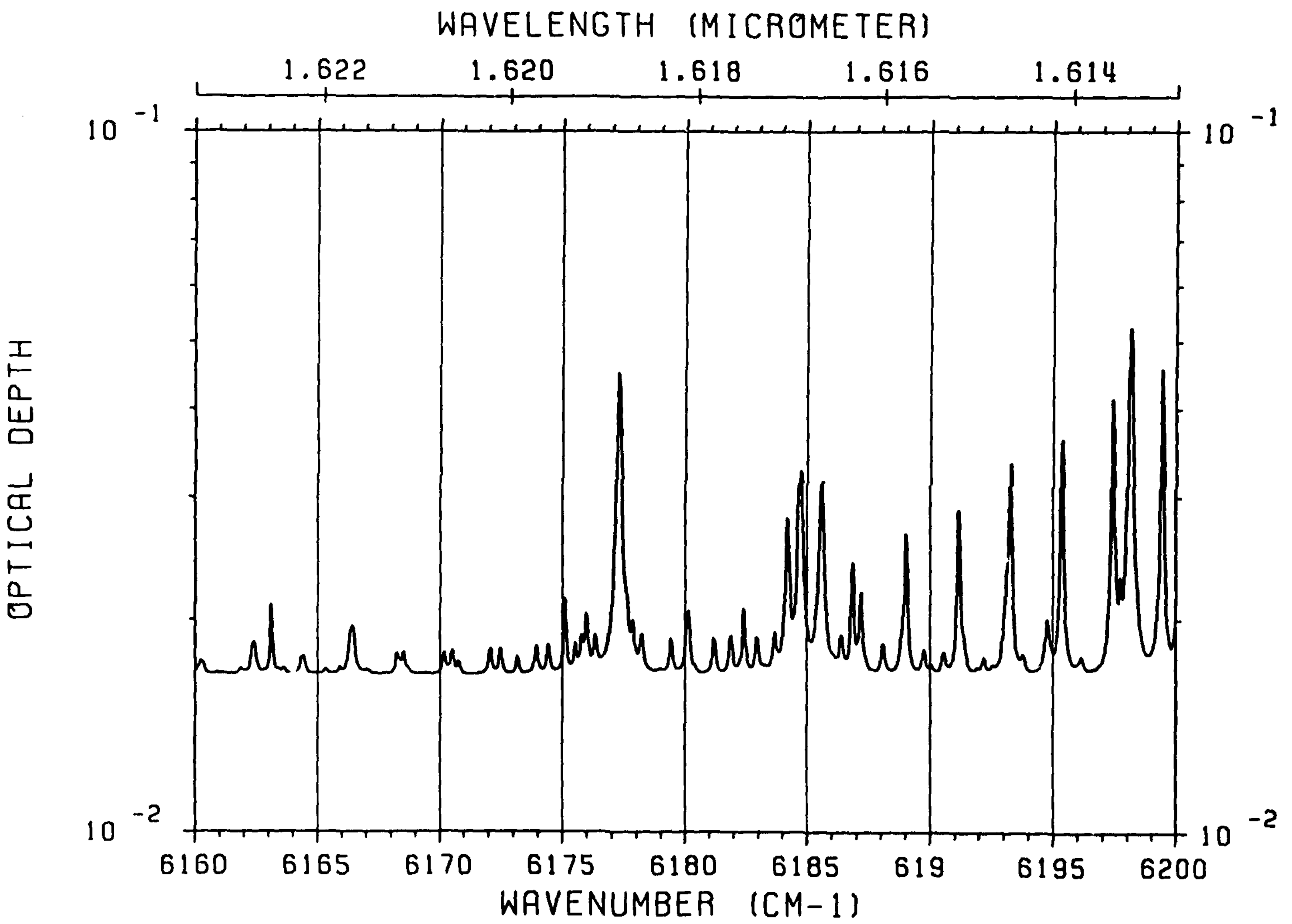
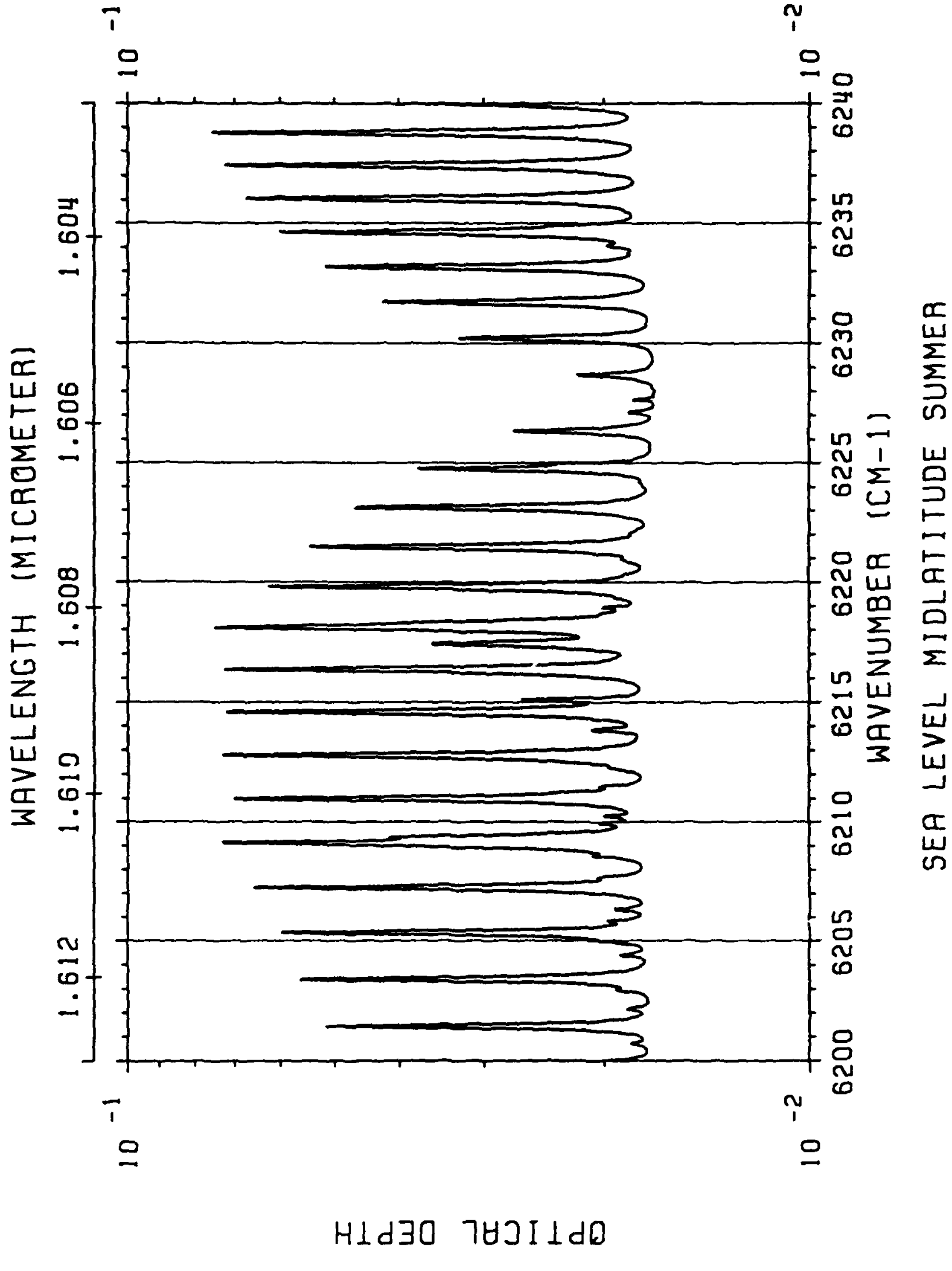
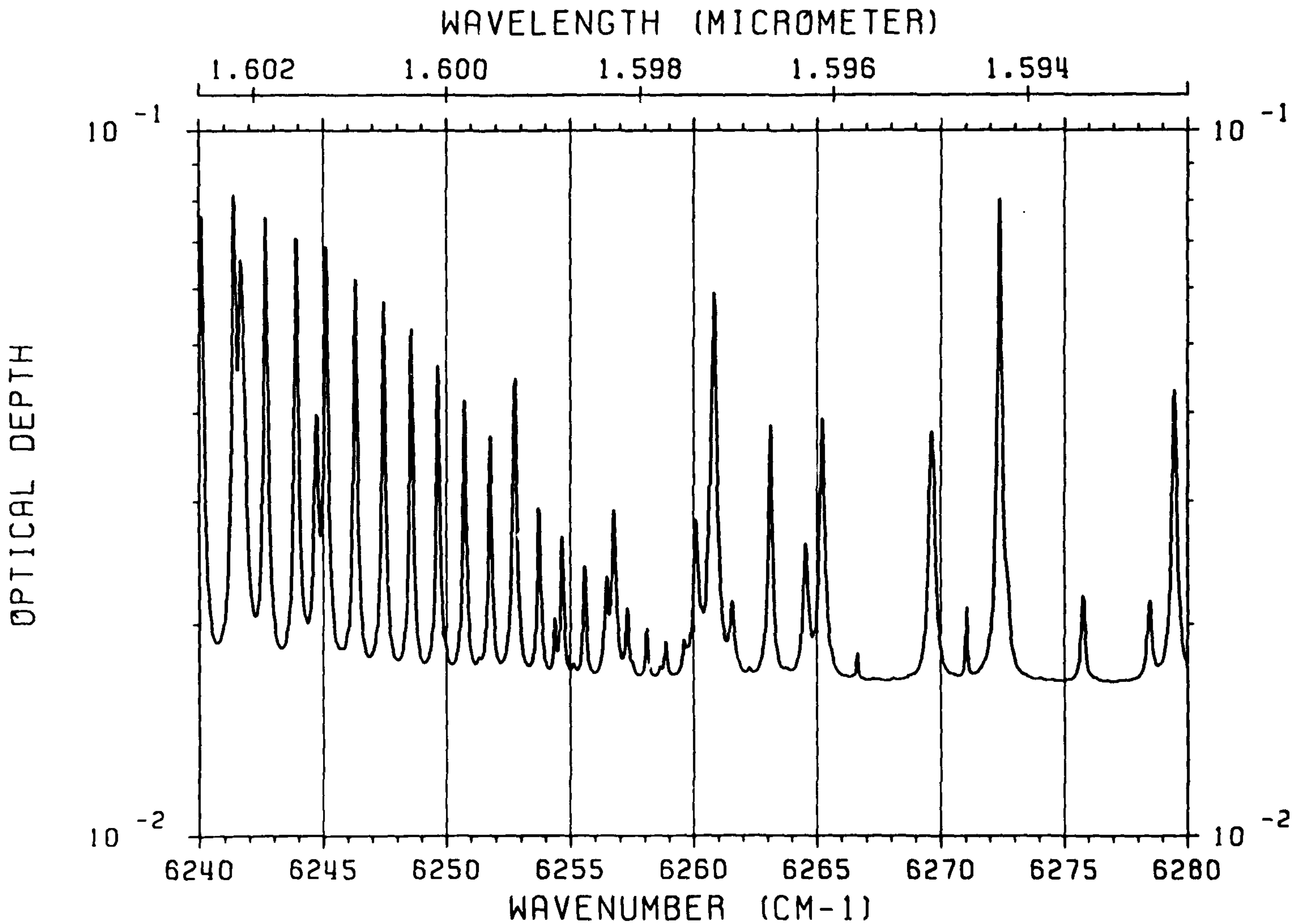


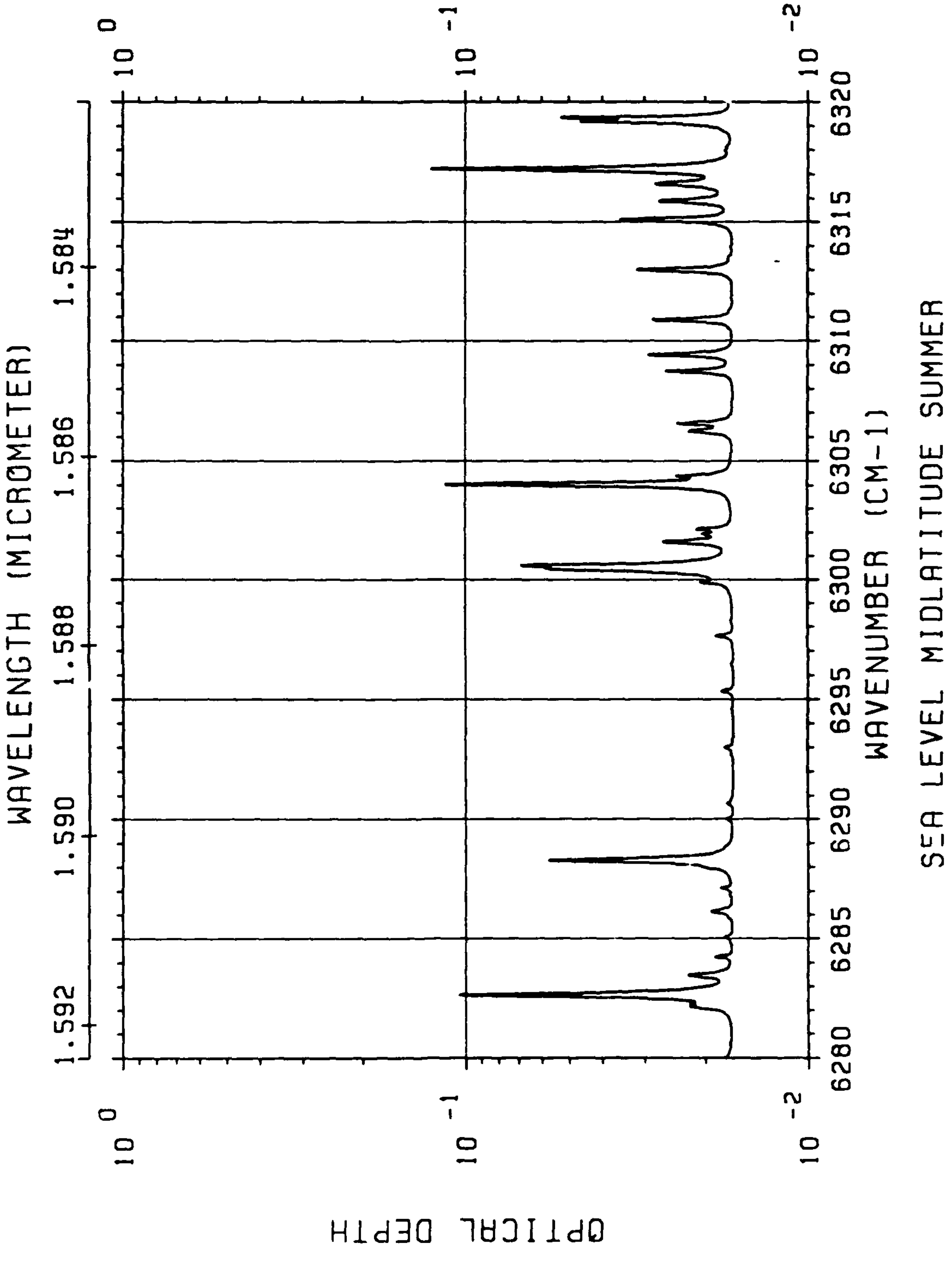
SEA LEVEL MIDLATITUDE SUMMER

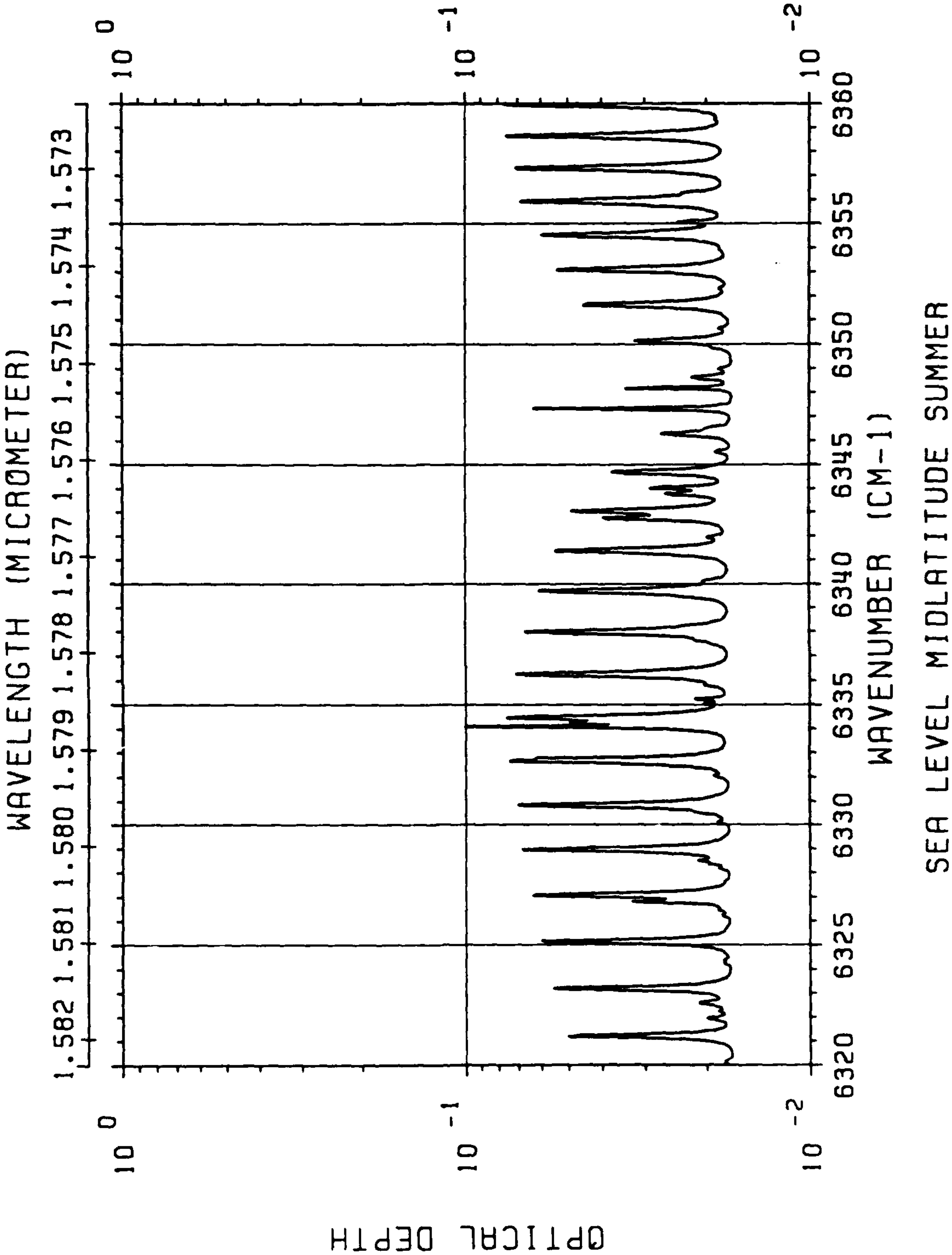


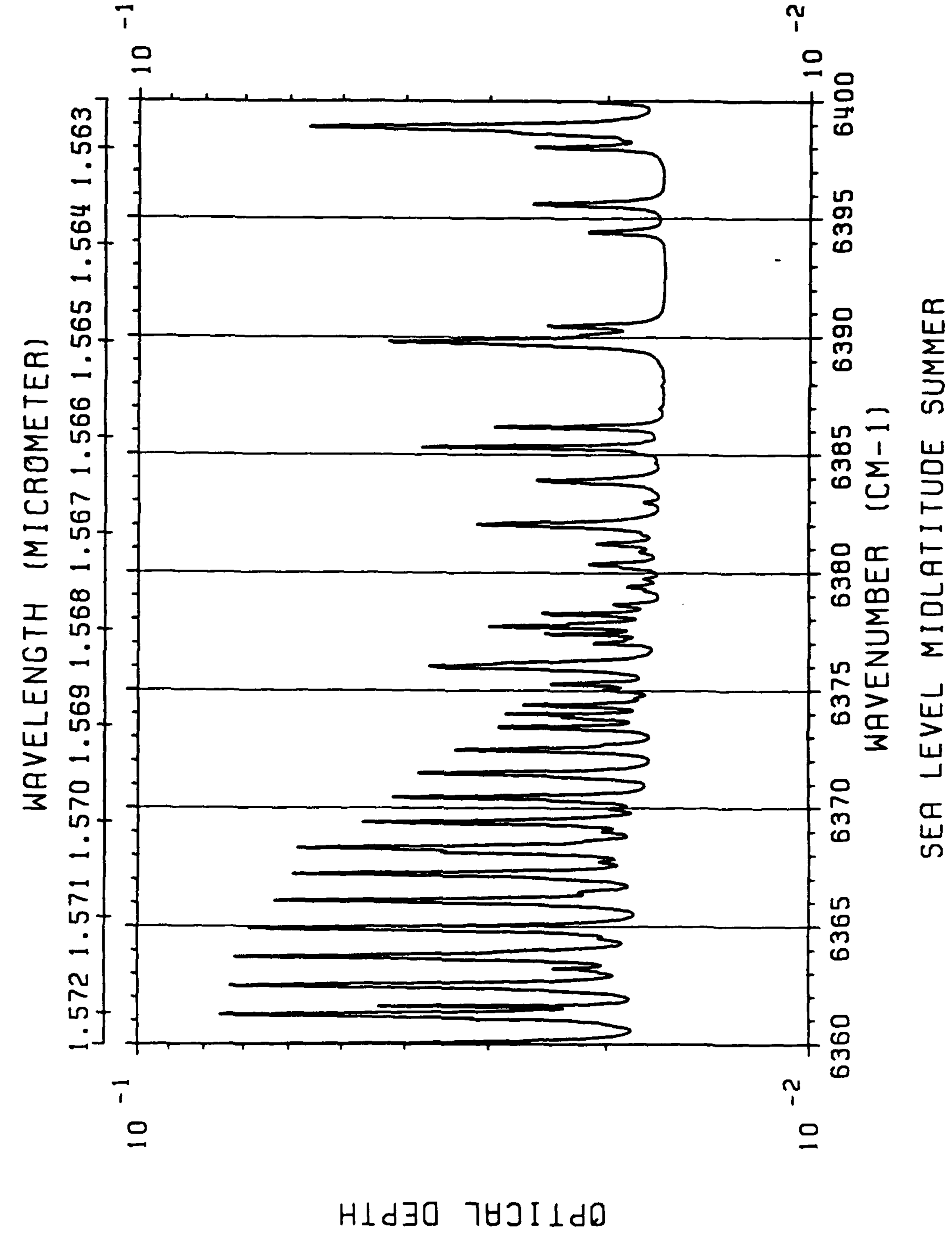
WAVELENGTH (MICROMETER)
1.604
1.606
1.608
1.610
1.612
WAVENUMBER (CM-1)
6200
6205
6210
6215
6220
6225
6230
6235
6240
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10 -1
10 -2

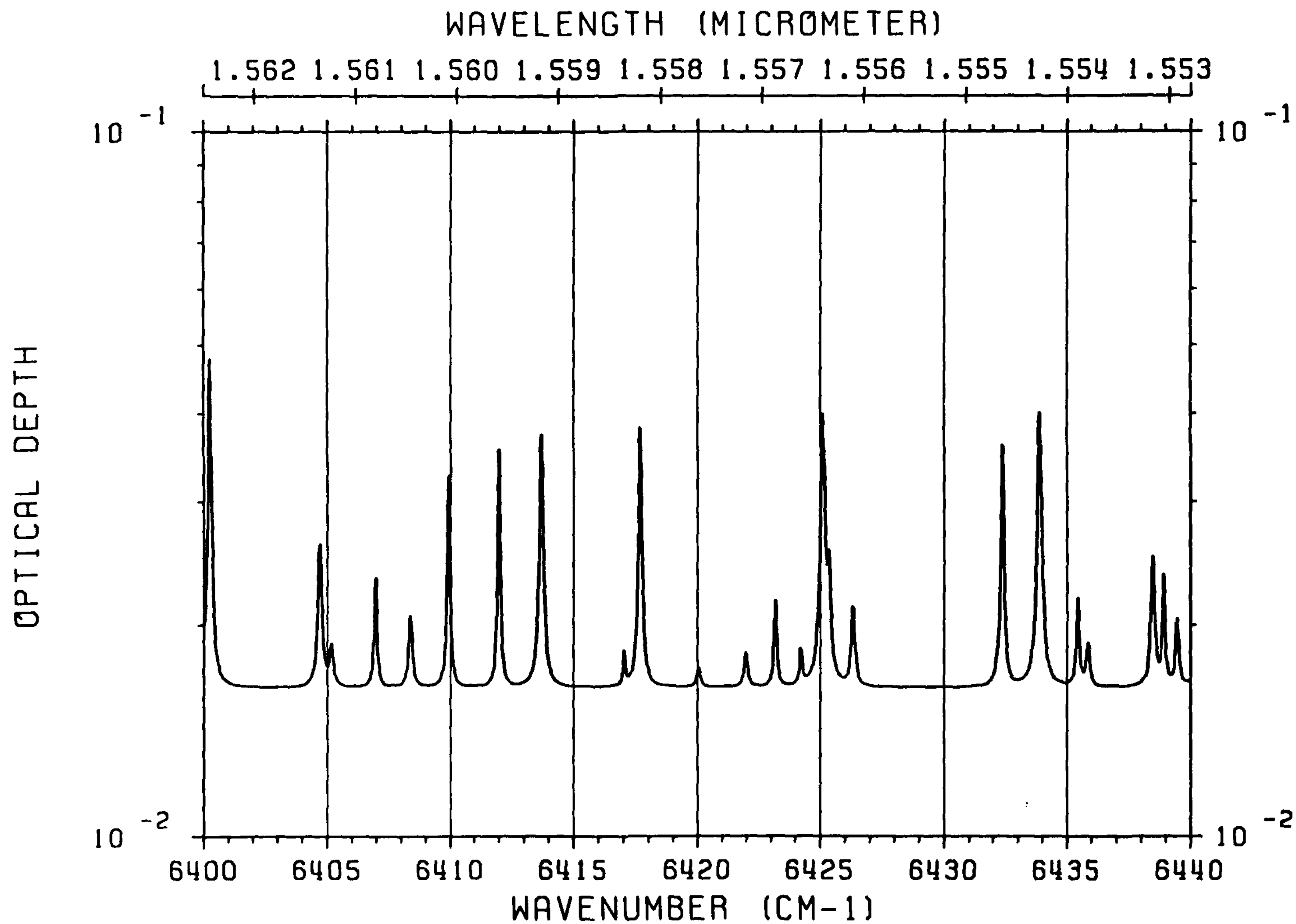


SEA LEVEL MIDLATITUDE SUMMER

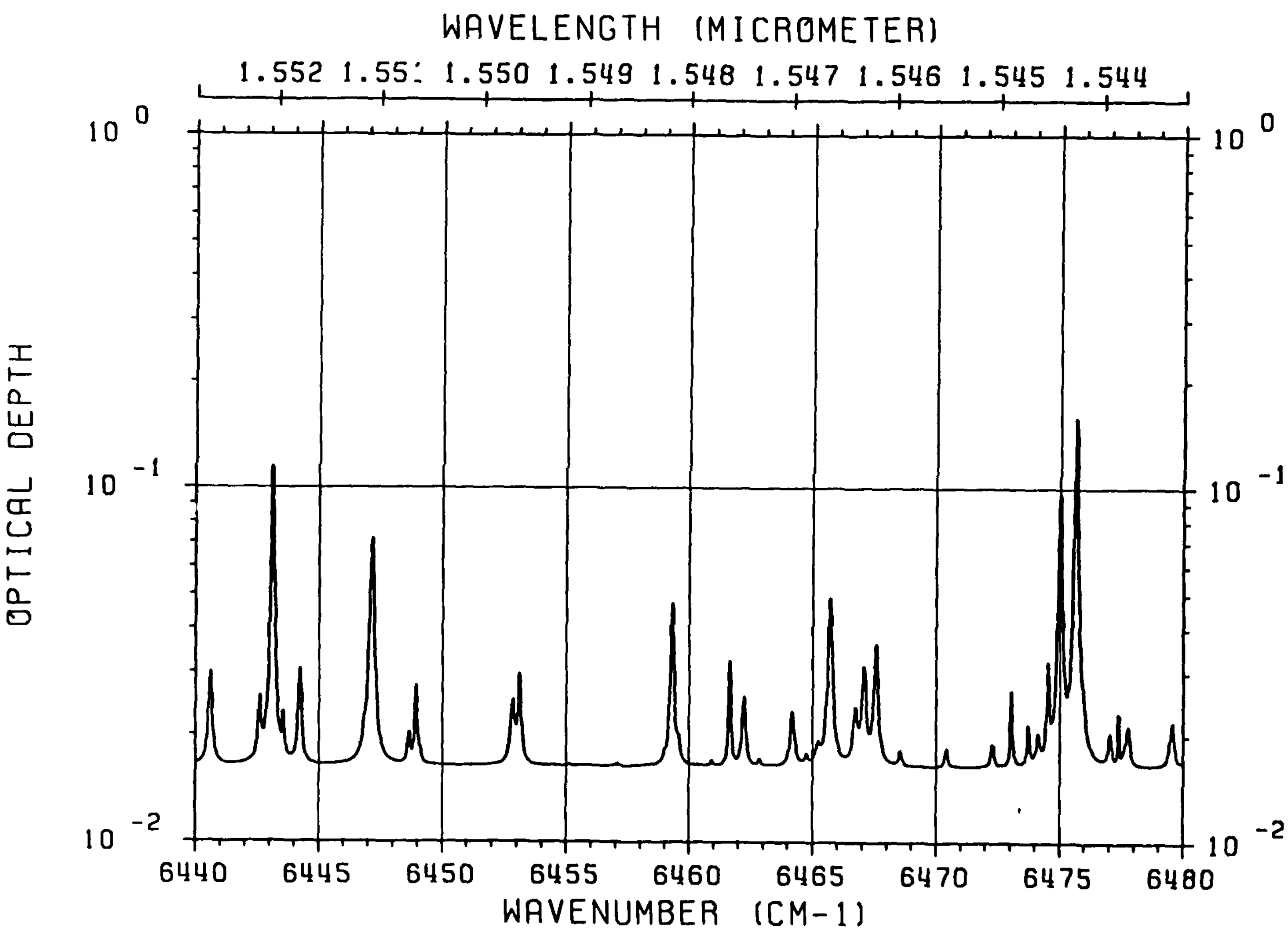

WAVELENGTH (MICROMETER)
1.592
1.590
1.588
1.586
1.584
WAVENUMBER (CM-1)
6280
6285
6290
6295
6300
6305
6310
6315
6320
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{0}
10^{-1}
10^{-2}


WAVELENGTH (MICROMETER)
1.582 1.581 1.581 1.580 1.580 1.579 1.578 1.578 1.577 1.577 1.576 1.576 1.575 1.575 1.574 1.573
WAVENUMBER (CM-1)
6320 6325 6330 6335 6340 6345 6350 6355 6360
OPTICAL DEPTH
10^{0} 10^{-1} 10^{-2}
SEA LEVEL MIDLATITUDE SUMMER

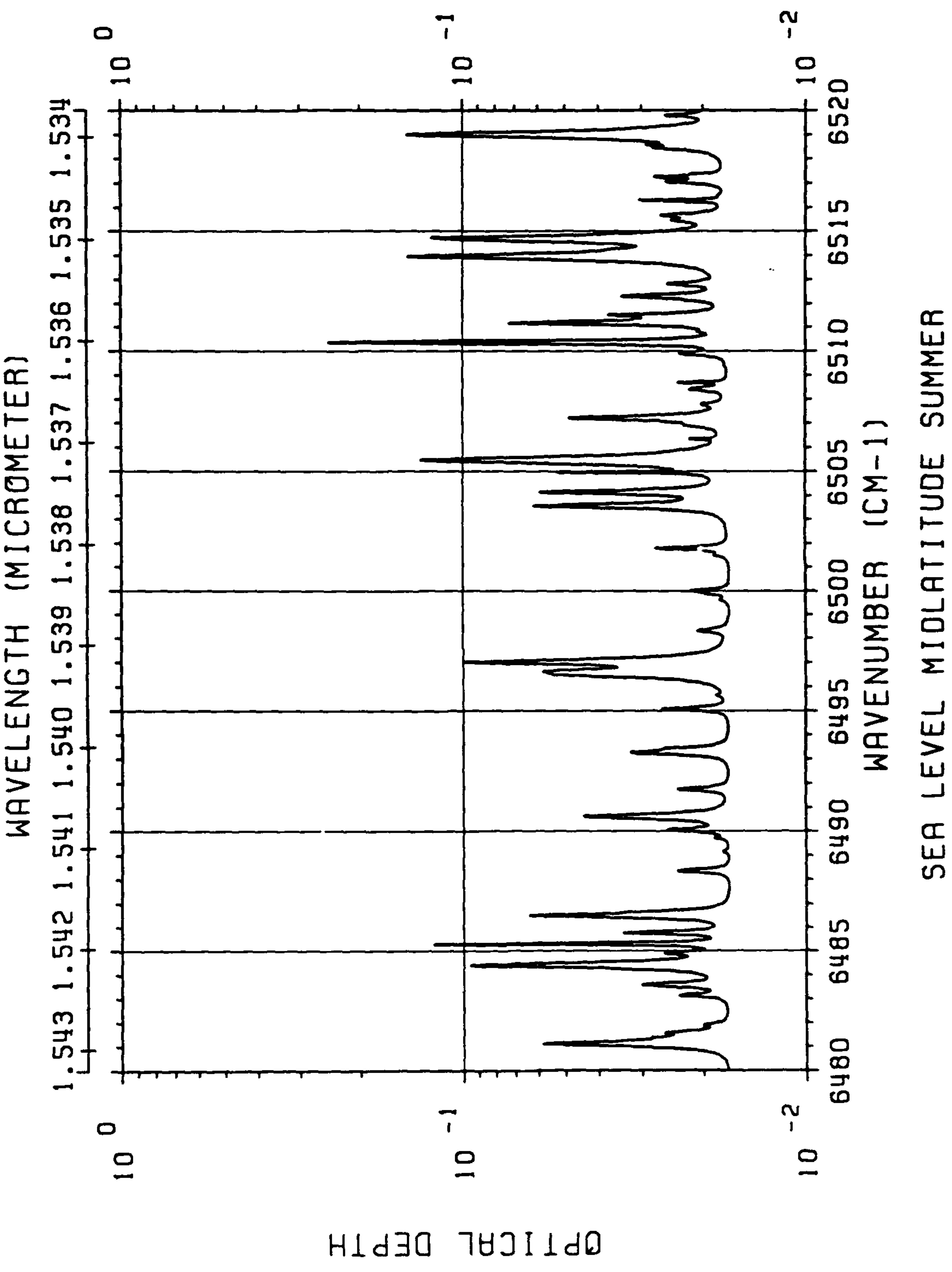

WAVELENGTH (MICROMETER)
1.572 1.571 1.570 1.569 1.568 1.567 1.566 1.565 1.564 1.563
WAVENUMBER (CM-1)
6360 6365 6370 6375 6380 6385 6390 6395 6400
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10 -1
10 -2



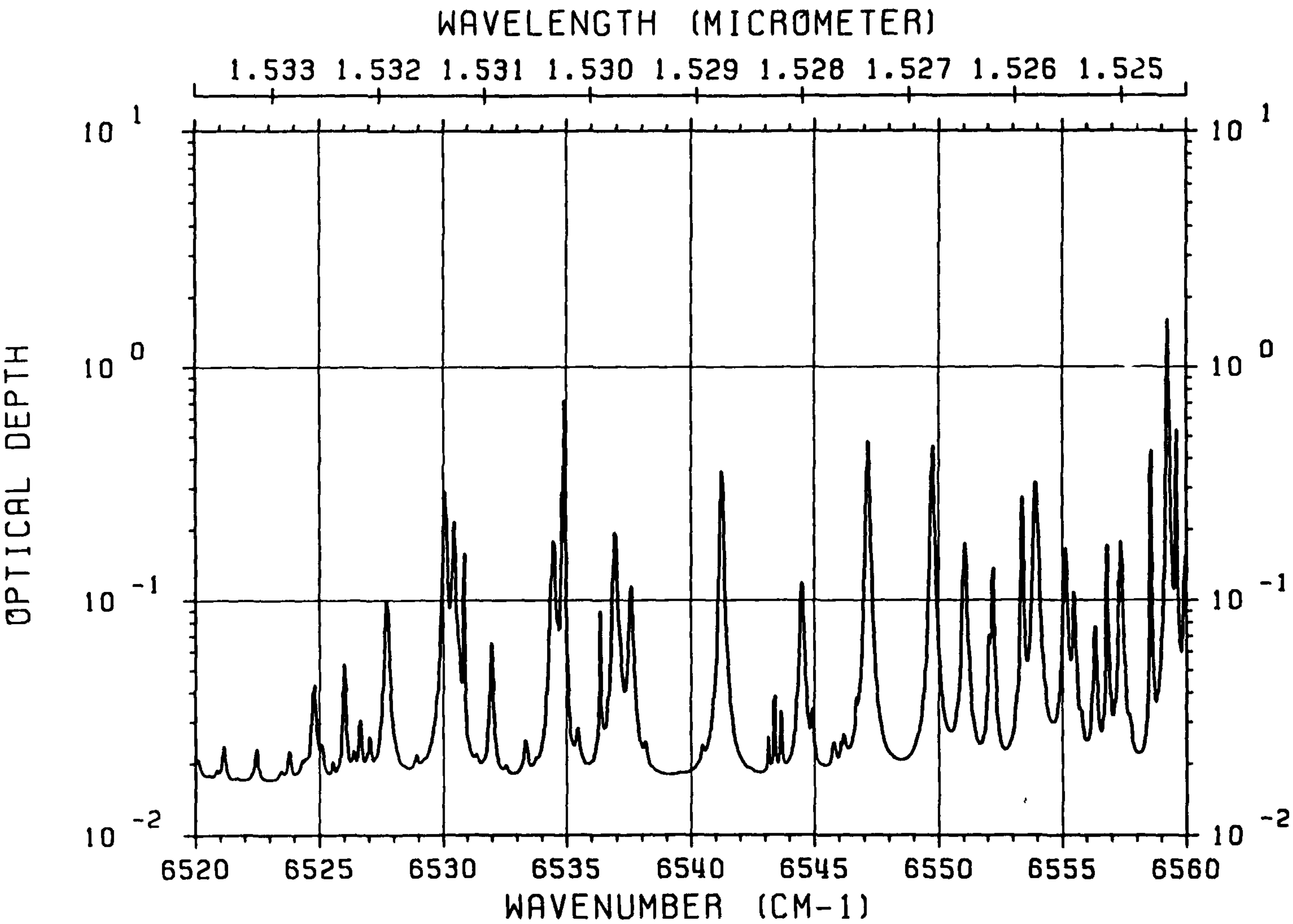
SEA LEVEL MIDLATITUDE SUMMER



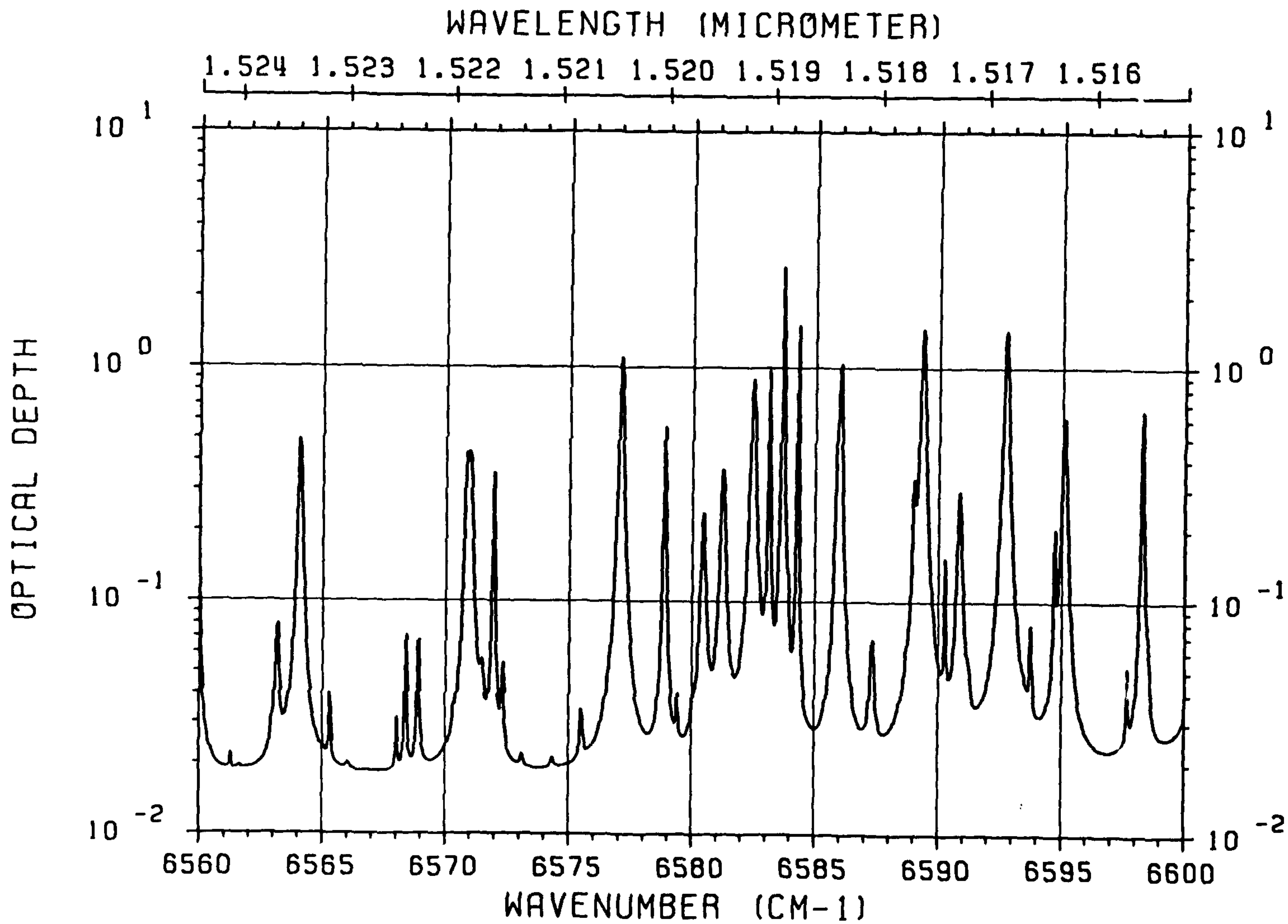
SEA LEVEL MIDLATITUDE SUMMER



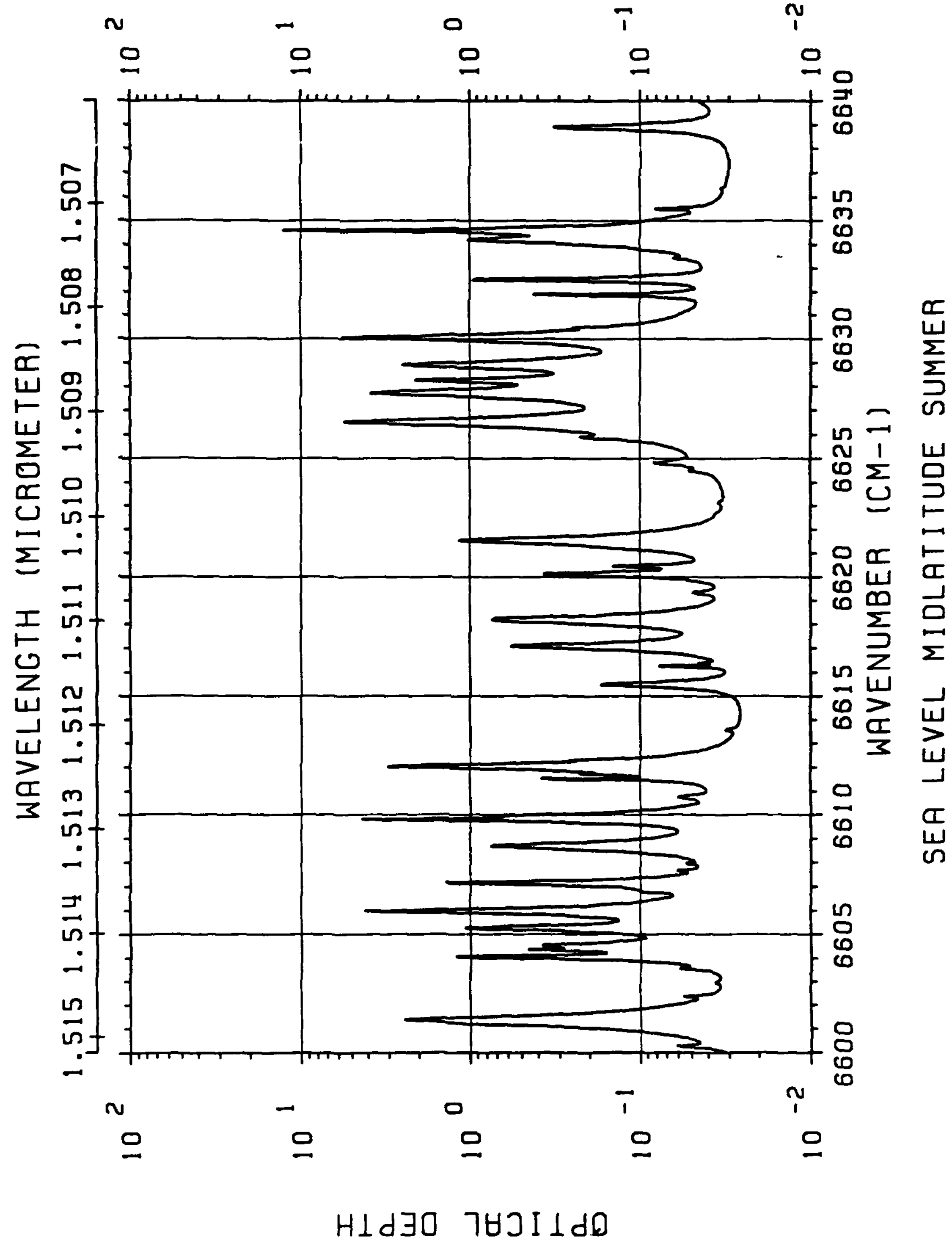
WAVELENGTH (MICROMETER)
1.543 1.542 1.541 1.540 1.539 1.538 1.537 1.536 1.535 1.534
WAVENUMBER (CM-1)
6480 6485 6490 6495 6500 6505 6510 6515 6520
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{0} 10^{-1} 10^{-2}

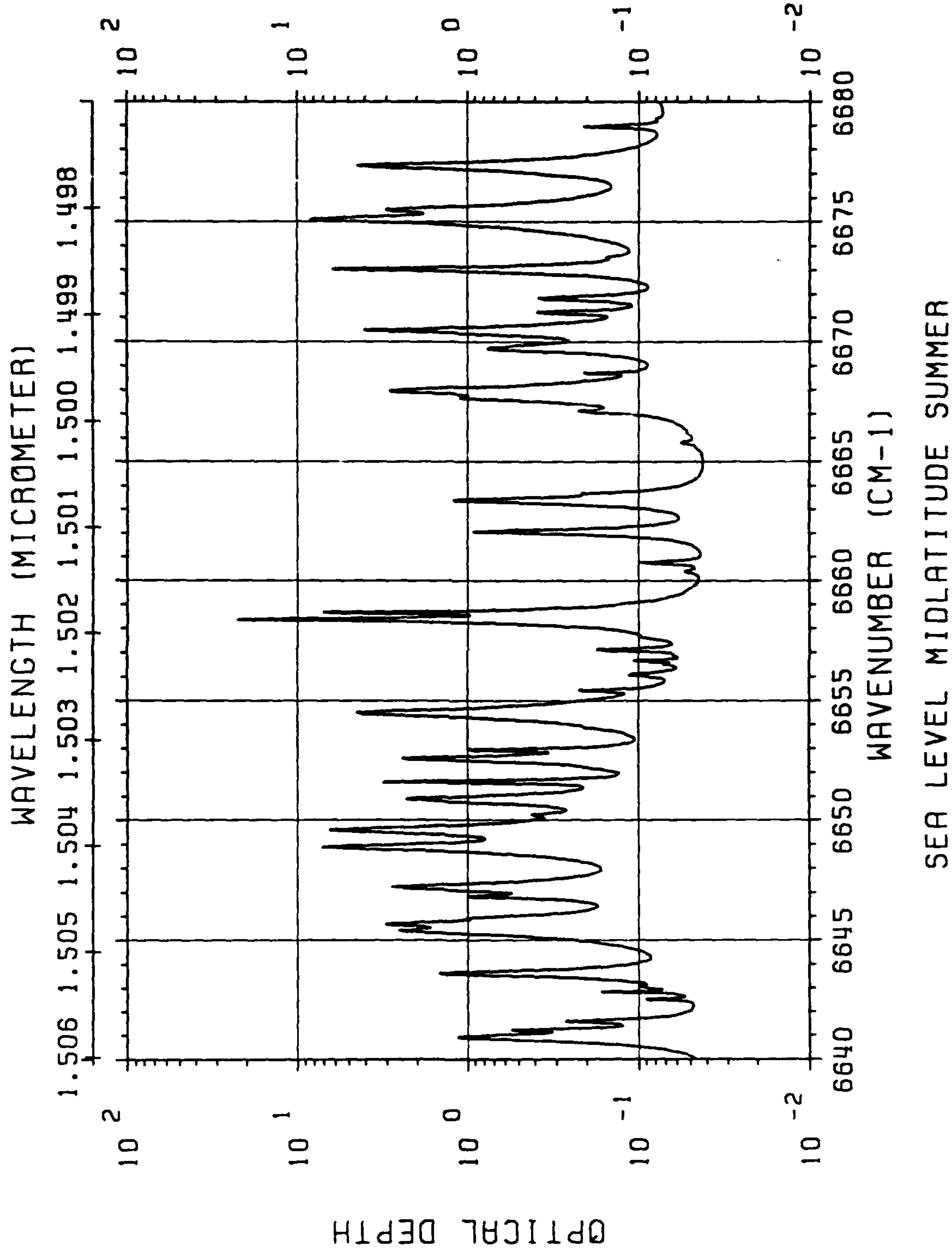


SEA LEVEL MIDLATITUDE SUMMER

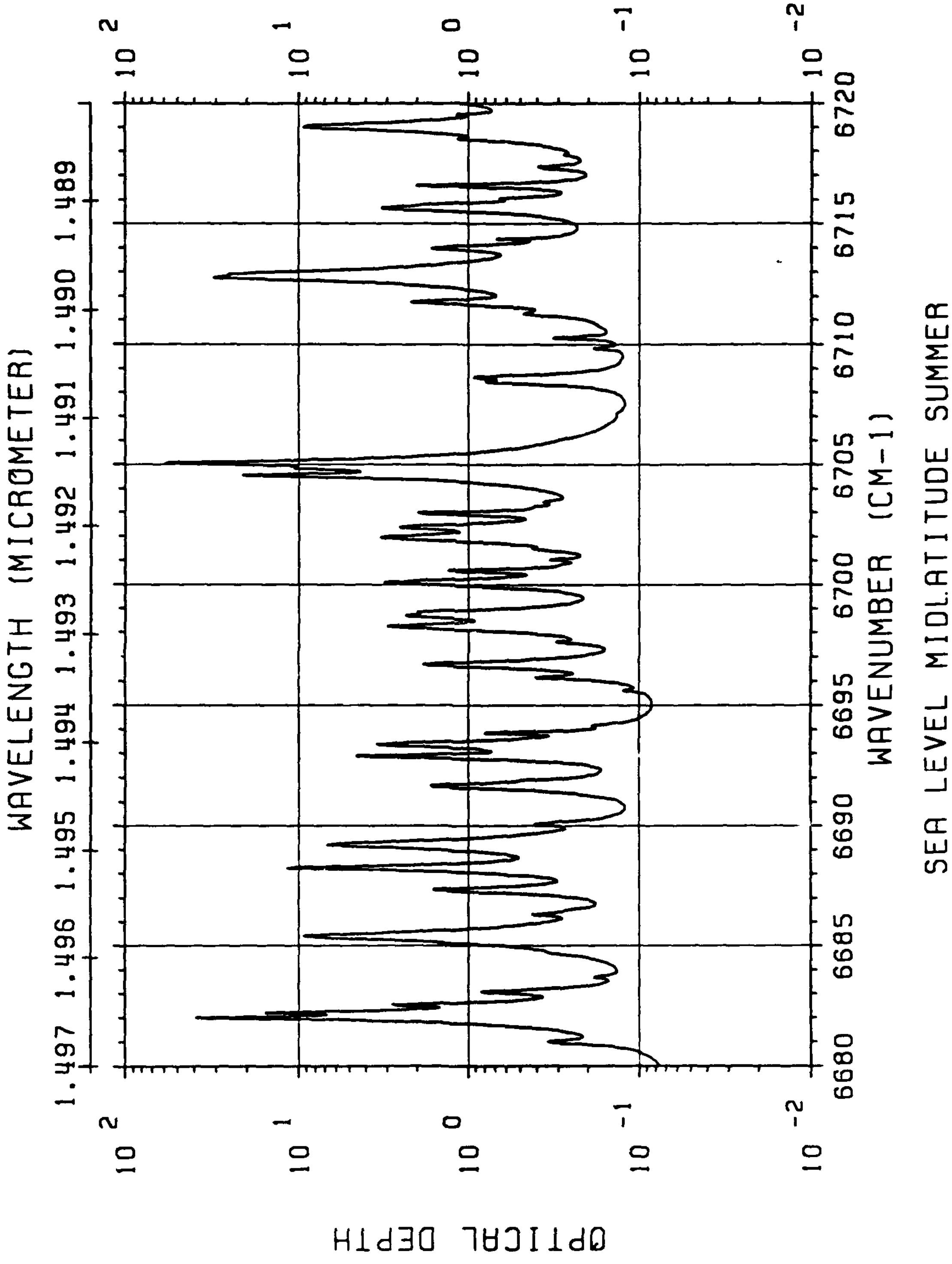


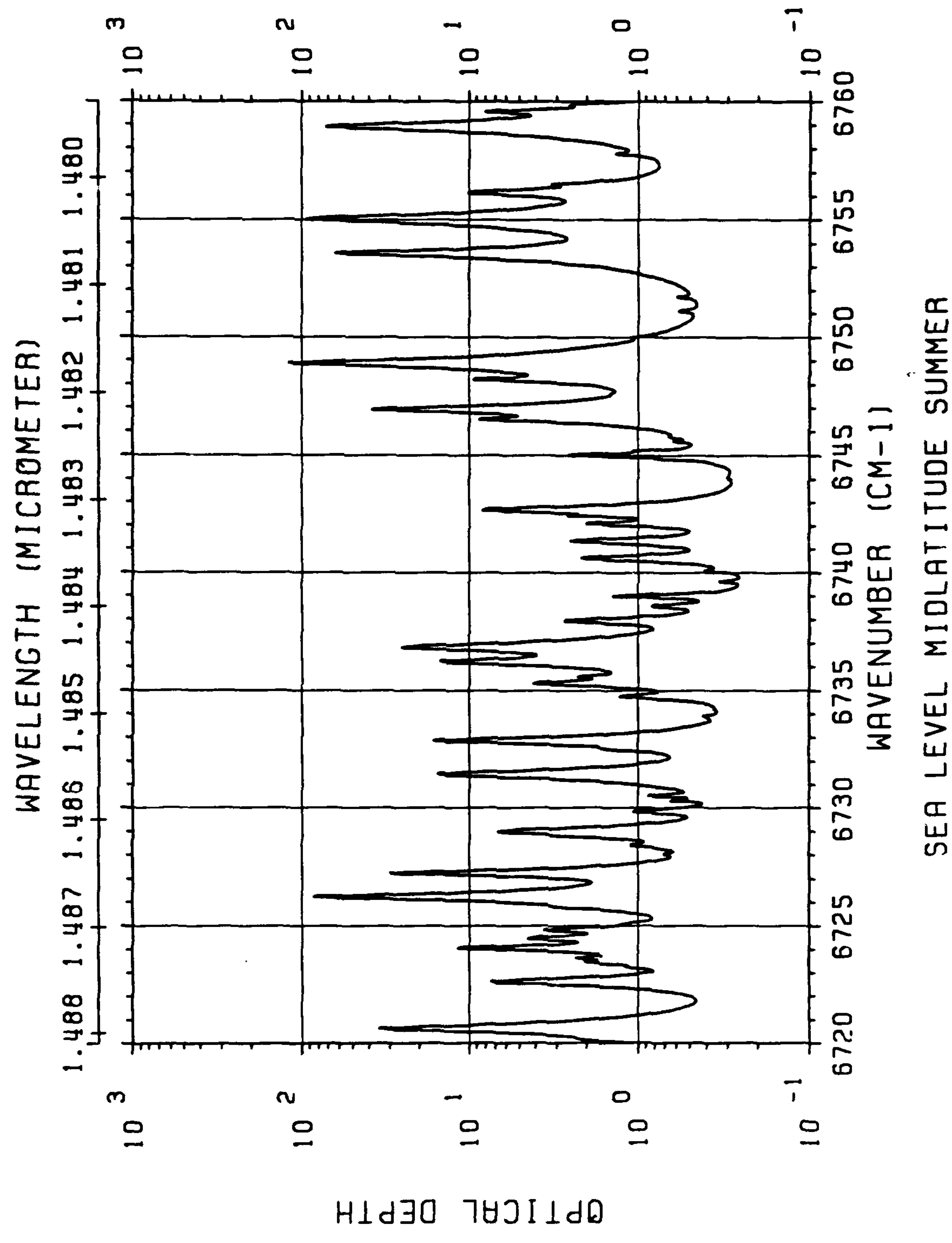
SEA LEVEL MIDLATITUDE SUMMER

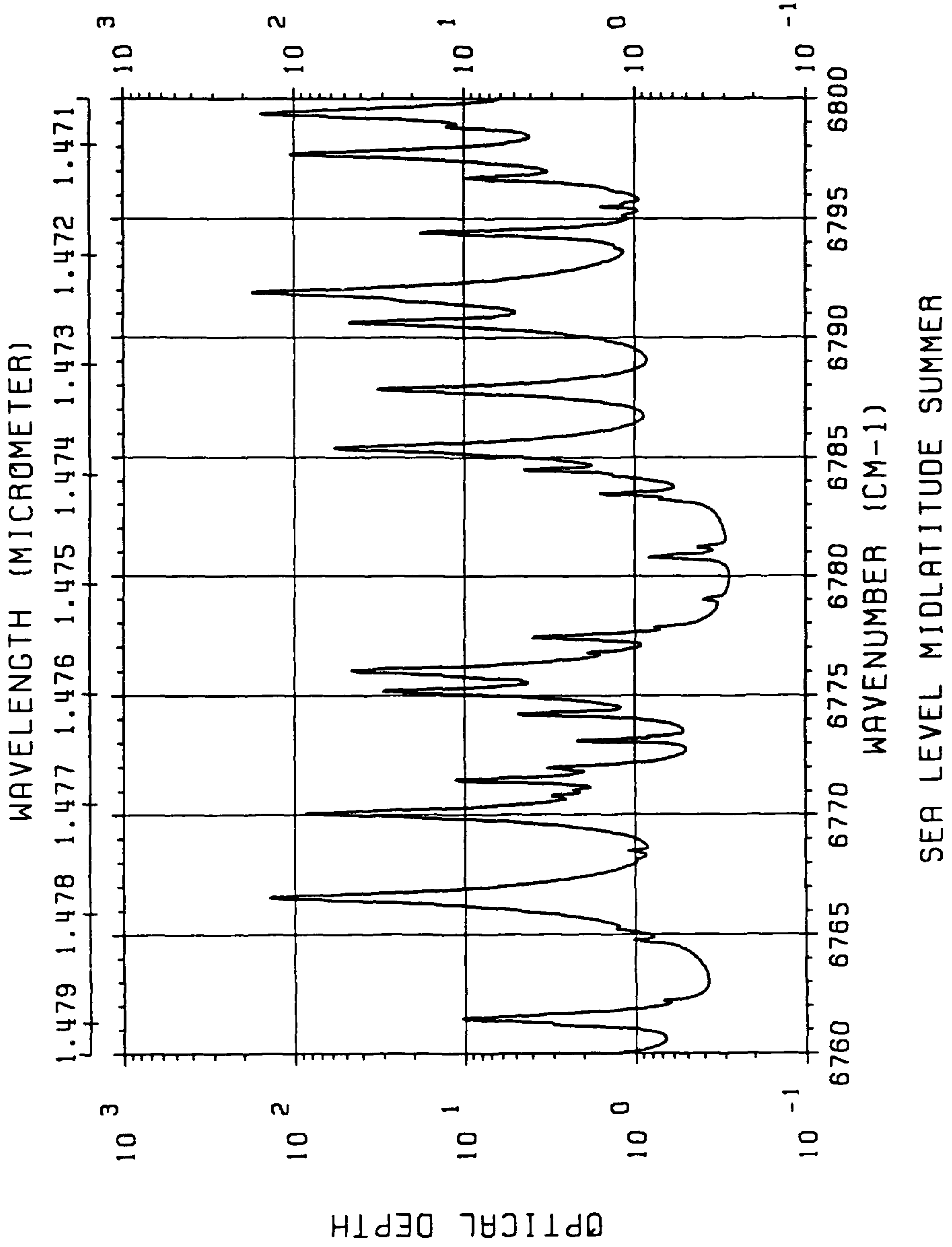

WAVELENGTH (MICROMETER)
1.515 1.514 1.513 1.512 1.511 1.510 1.509 1.508 1.507
WAVENUMBER (CM-1)
6600 6605 6610 6615 6620 6625 6630 6635 6640
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{2} 10^{1} 10^{0} 10^{-1} 10^{-2}

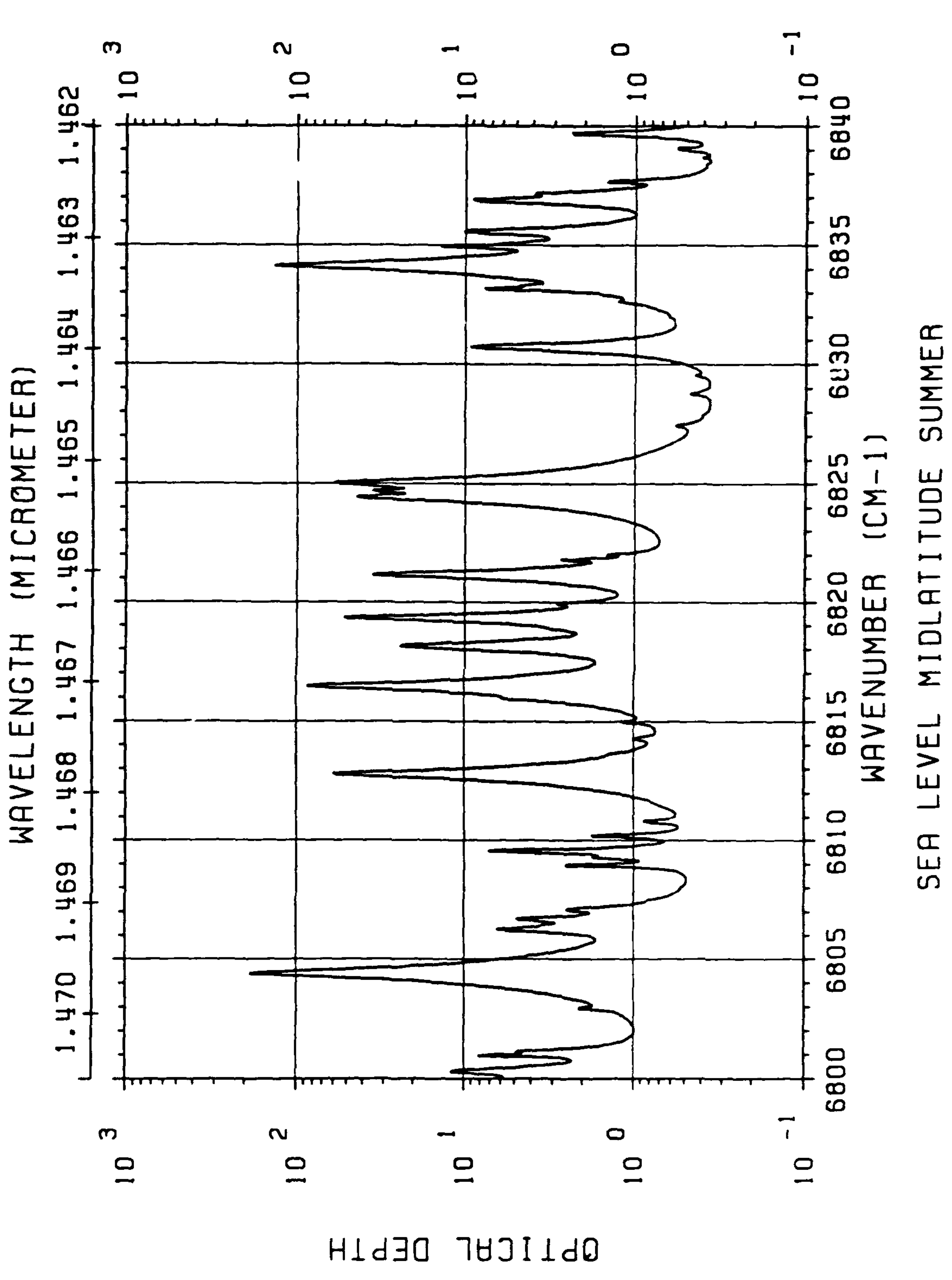


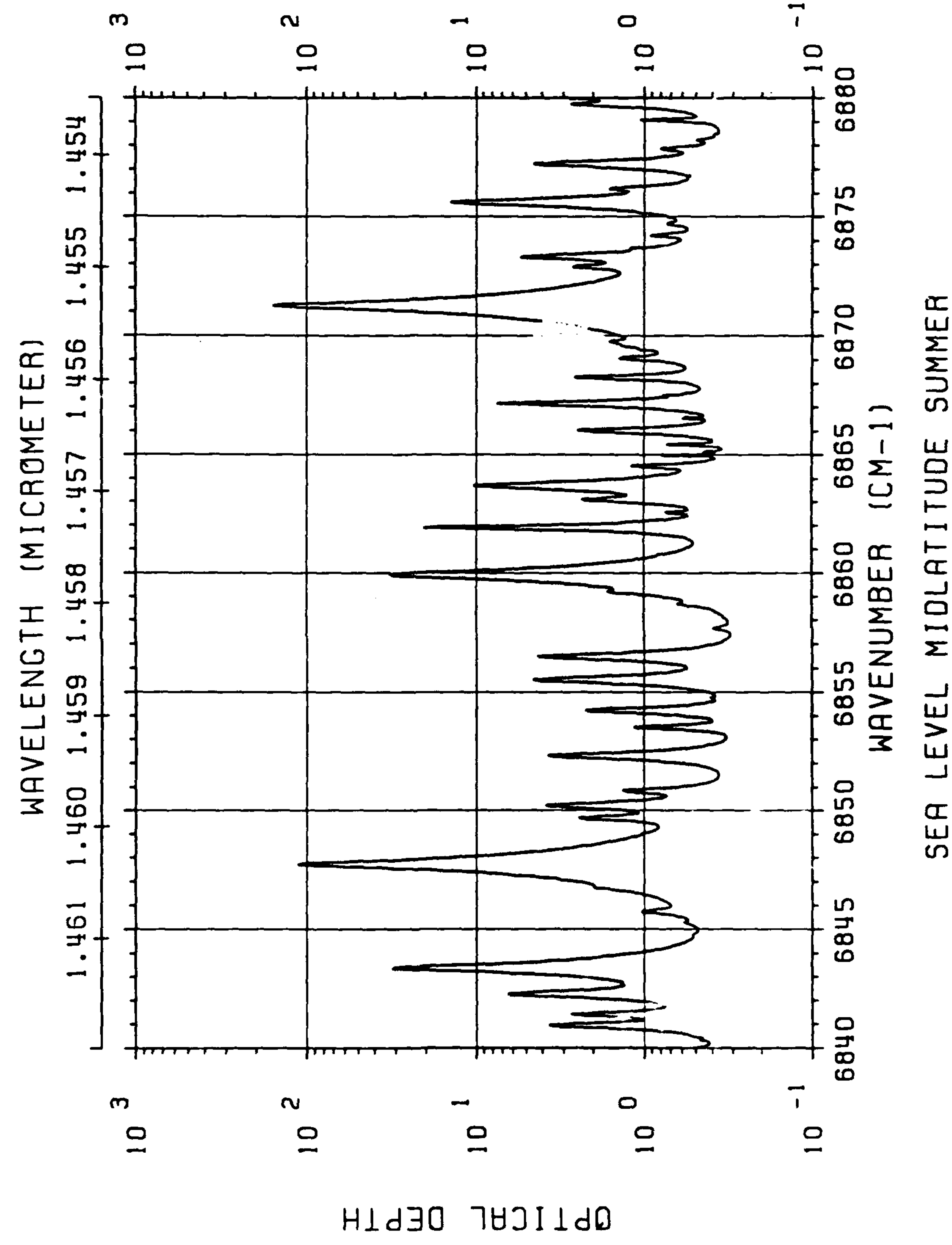
WAVELENGTH (MICROMETER)
1.506 1.505 1.505 1.504 1.504 1.503 1.503 1.502 1.502 1.501 1.501 1.500 1.500 1.499 1.499 1.498
6640 6645 6650 6655 6660 6665 6670 6675 6680
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{2} 10^{1} 10^{0} 10^{-1} 10^{-2}

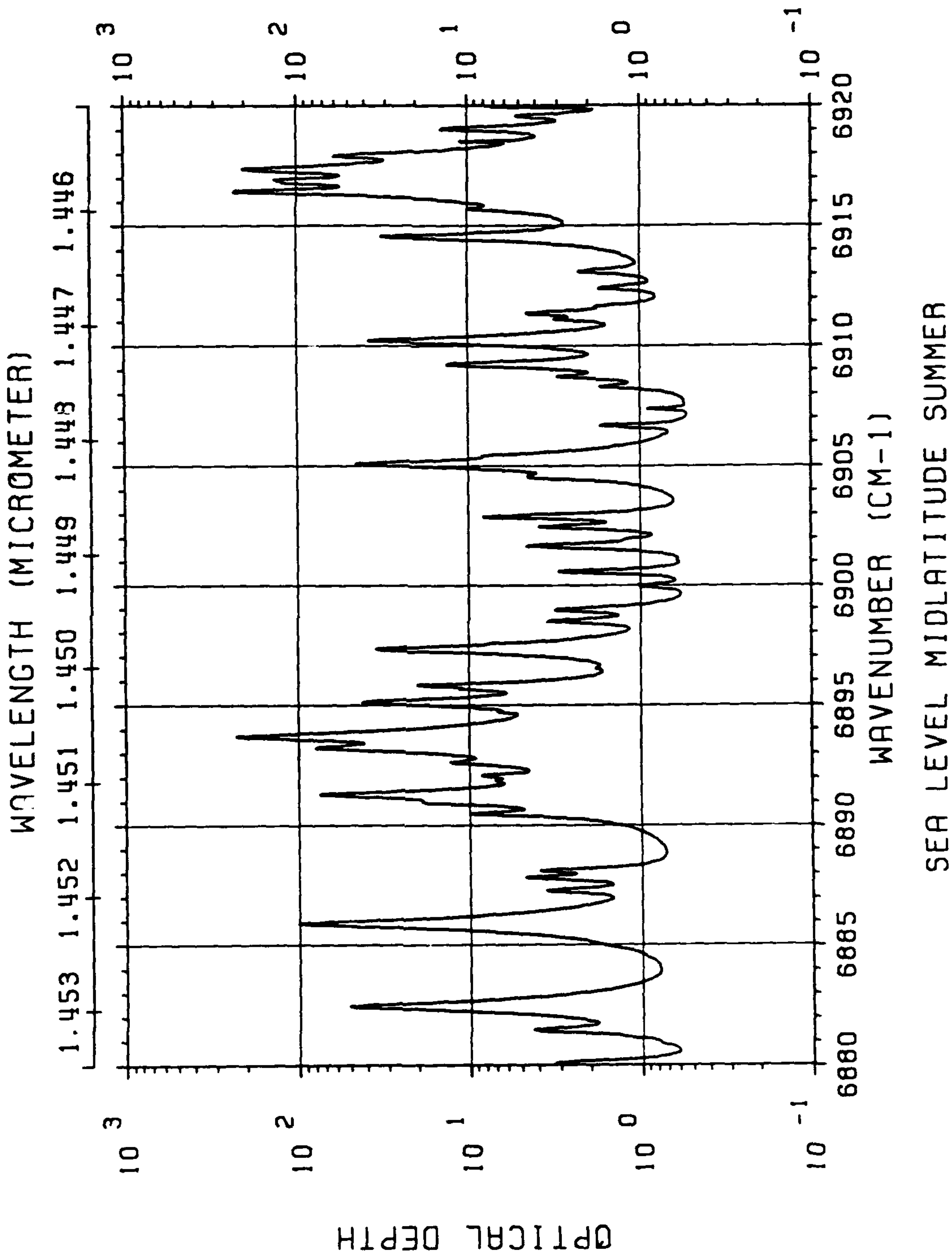

WAVELENGTH (MICROMETER)
1.497 1.496 1.495 1.494 1.493 1.492 1.491 1.490 1.489
WAVENUMBER (CM-1)
6680 6685 6690 6695 6700 6705 6710 6715 6720
OPTICAL DEPTH
10^{2} 10^{1} 10^{0} 10^{-1} 10^{-2}
SEA LEVEL MIDLATITUDE SUMMER

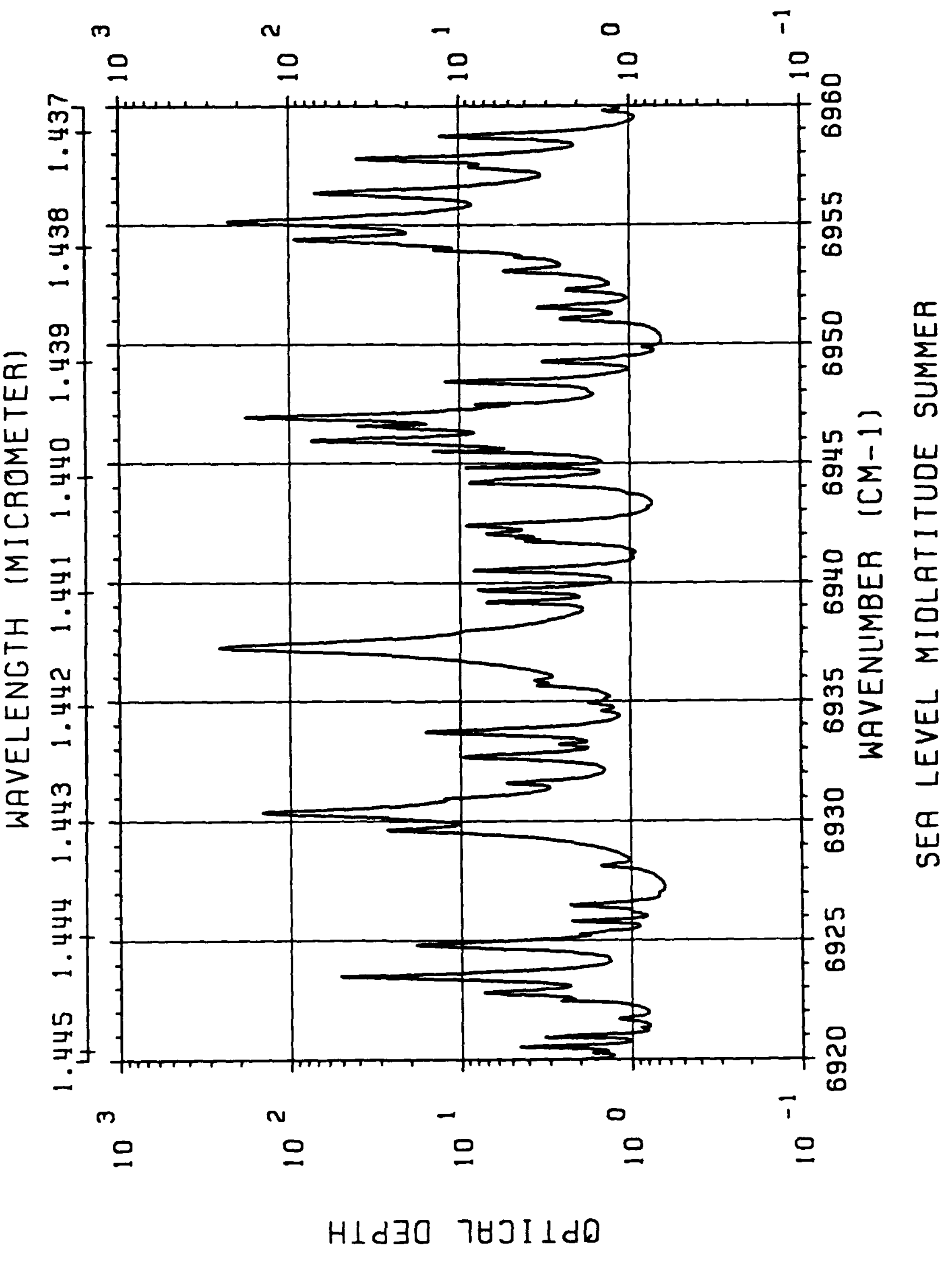

WAVELENGTH (MICRØMETER)
1.488 1.487 1.487 1.486 1.486 1.485 1.485 1.484 1.484 1.483 1.483 1.482 1.482 1.481 1.481 1.480 1.480
6720 6725 6730 6735 6740 6745 6750 6755 6760
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^-1 10^0 10^1 10^2 10^3

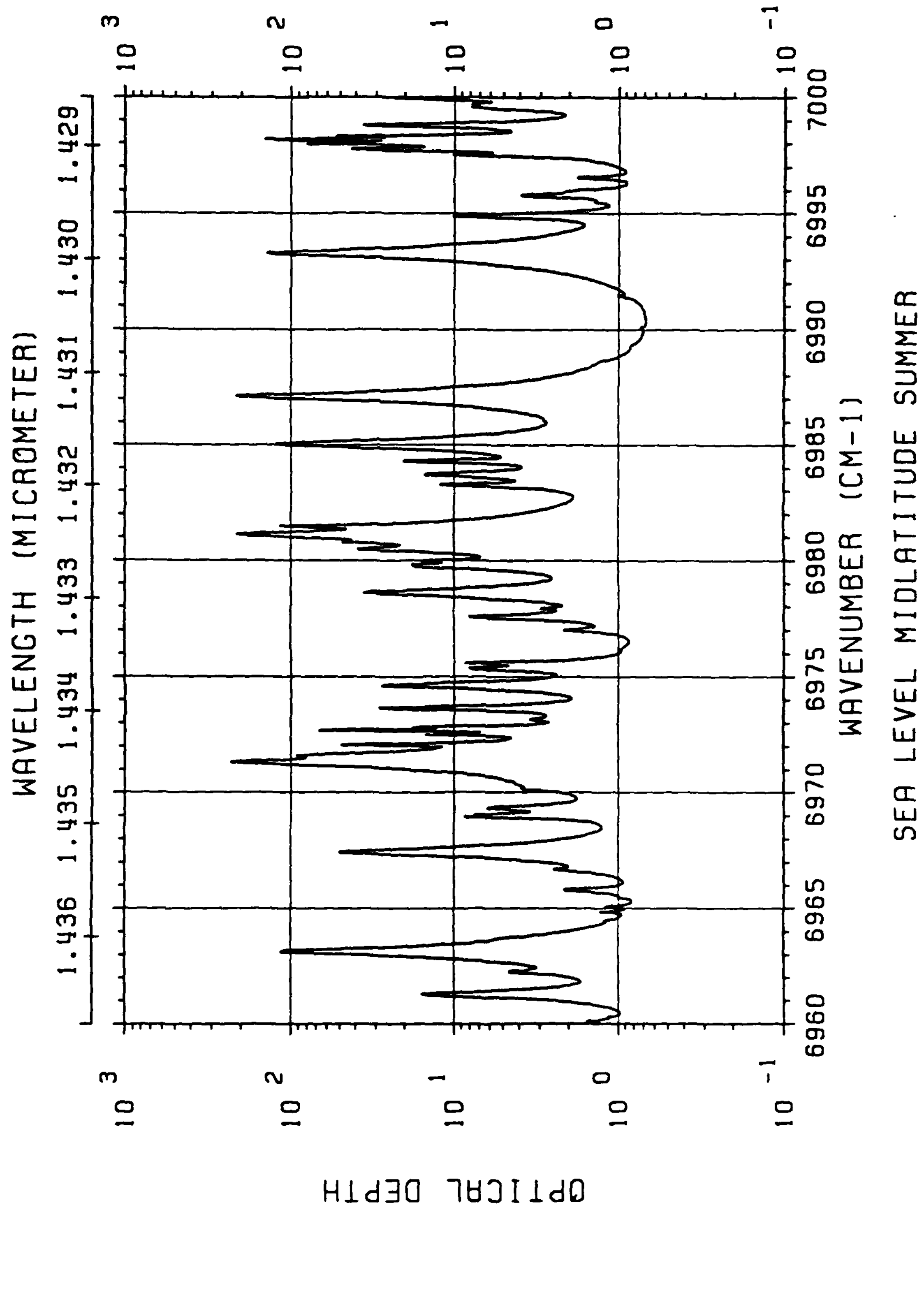

WAVELENGTH (MICROMETER)
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH

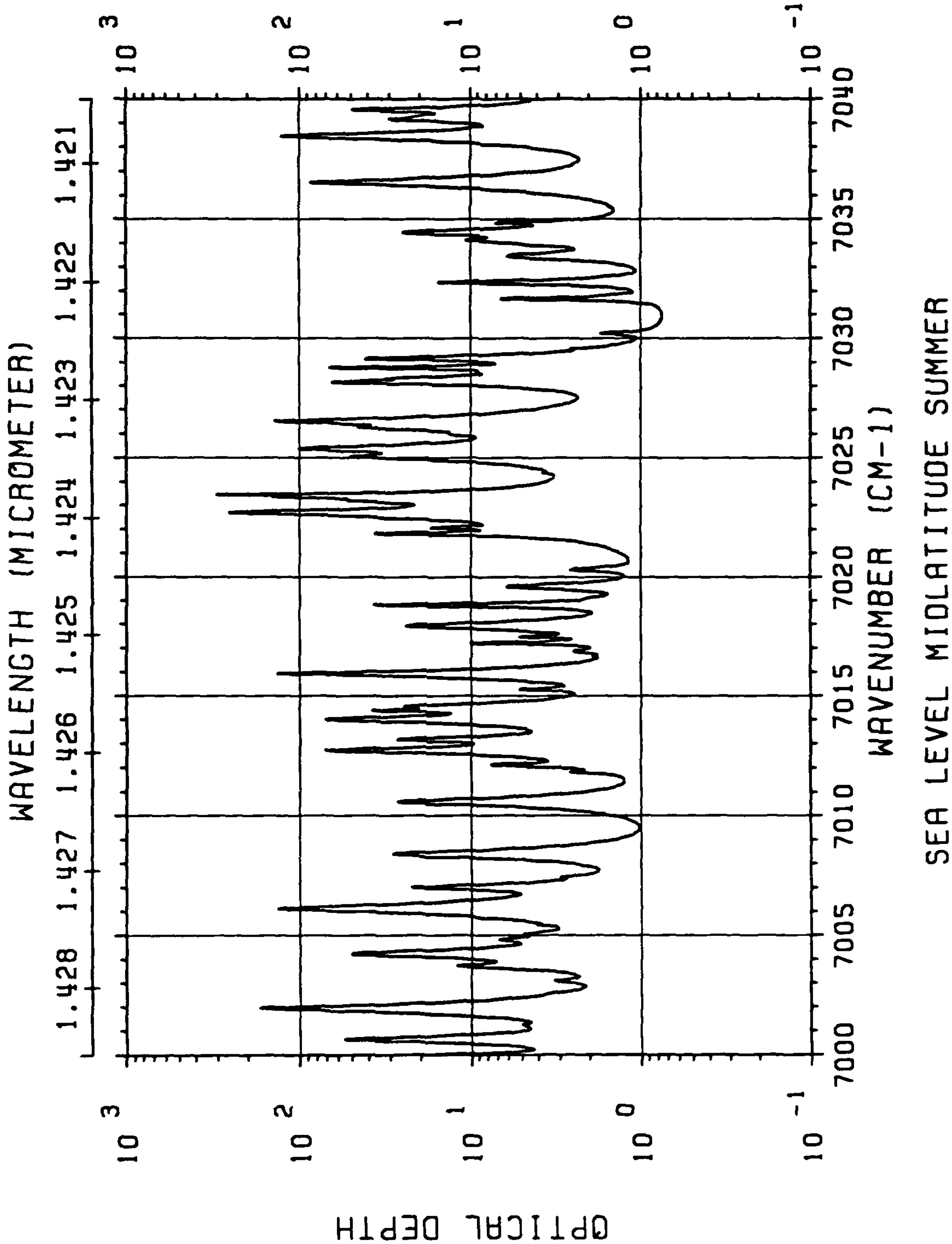

WAVELENGTH (MICROMETER)
1.470
1.469
1.468
1.467
1.466
1.465
1.464
1.463
1.462
OPTICAL DEPTH
10 3
10 2
10 1
10 0
10 -1
6800
6805
6810
6815
6820
6825
6830
6835
6840
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.461 1.460 1.459 1.458 1.457 1.456 1.455 1.454
WAVENUMBER (CM-1)
6840 6845 6850 6855 6860 6865 6870 6875 6880
OPTICAL DEPTH
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
SEA LEVEL MIDLATITUDE SUMMER

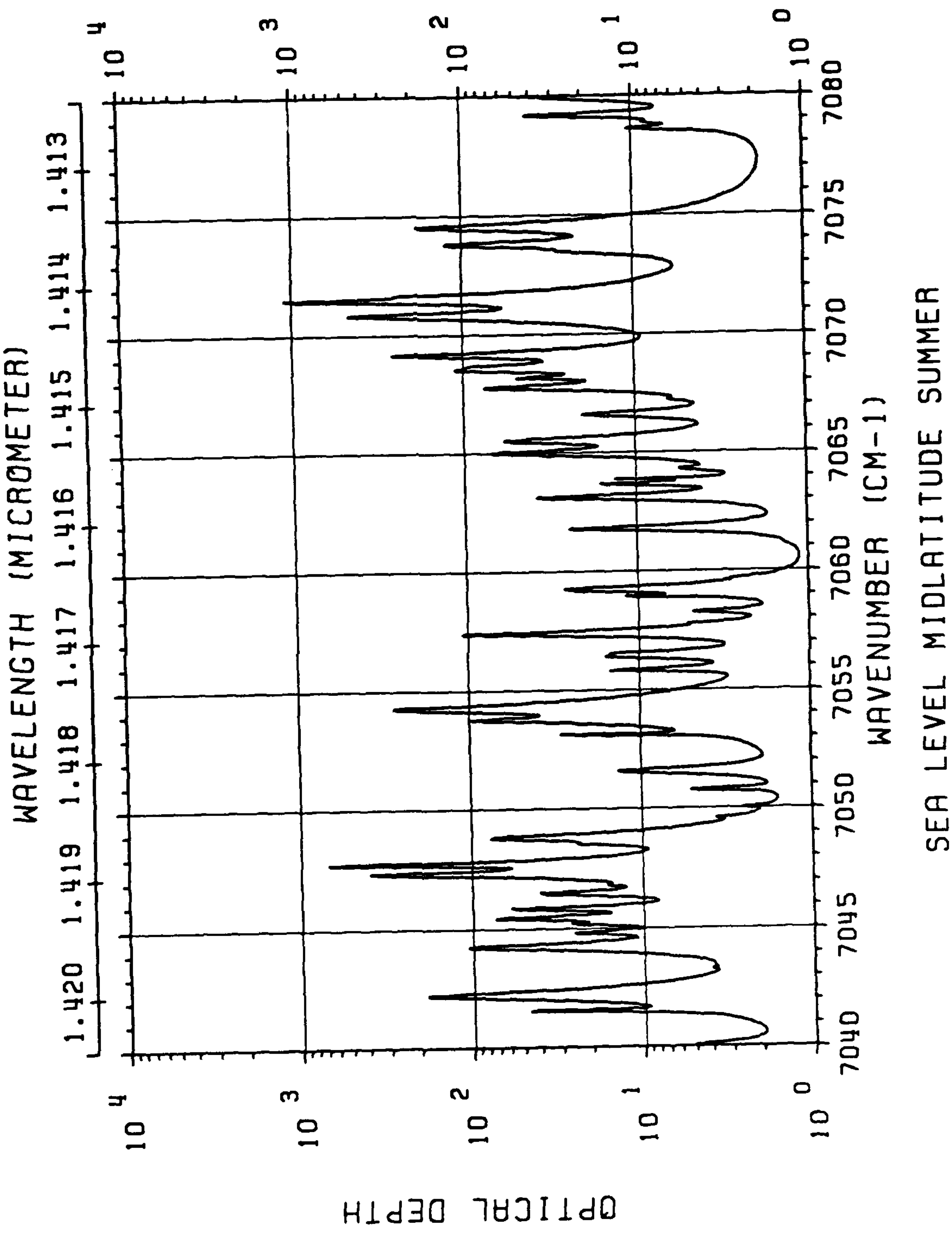

WAVELENGTH (MICROMETER)
1.453
1.452
1.451
1.450
1.449
1.448
1.447
1.446
OPTICAL DEPTH
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
6880
6885
6890
6895
6900
6905
6910
6915
6920
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

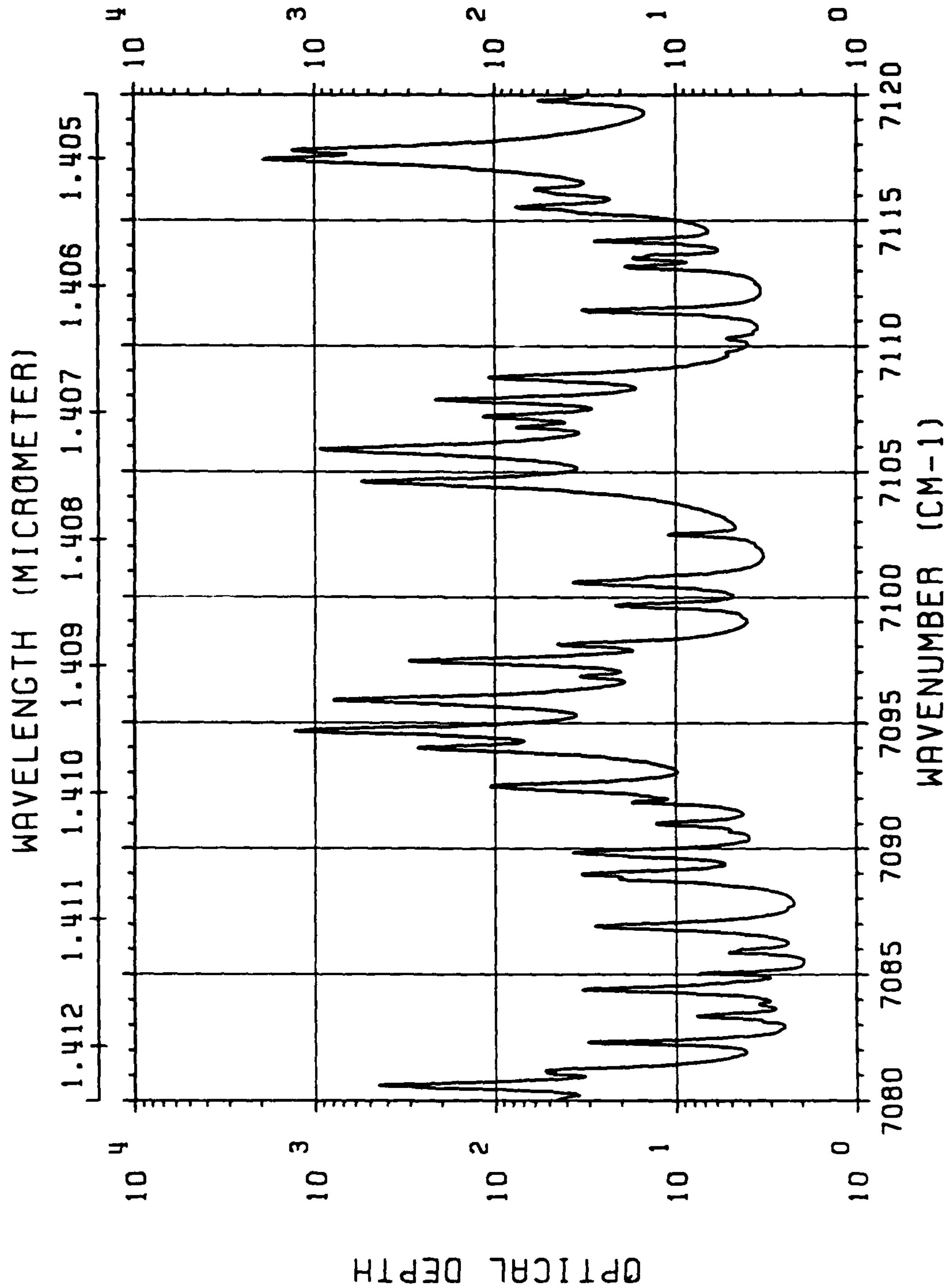

WAVELENGTH (MICROMETER)
1.445 1.444 1.444 1.443 1.443 1.442 1.442 1.441 1.441 1.440 1.440 1.439 1.439 1.438 1.438 1.437
OPTICAL DEPTH
10^{3} 10^{2} 10^{1} 10^{0} 10^{-1}
6920 6925 6930 6935 6940 6945 6950 6955 6960
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.436
1.435
1.434
1.433
1.432
1.431
1.430
1.429
OPTICAL DEPTH
10^3
10^2
10^1
10^0
10^-1
6960
6965
6970
6975
6980
6985
6990
6995
7000
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

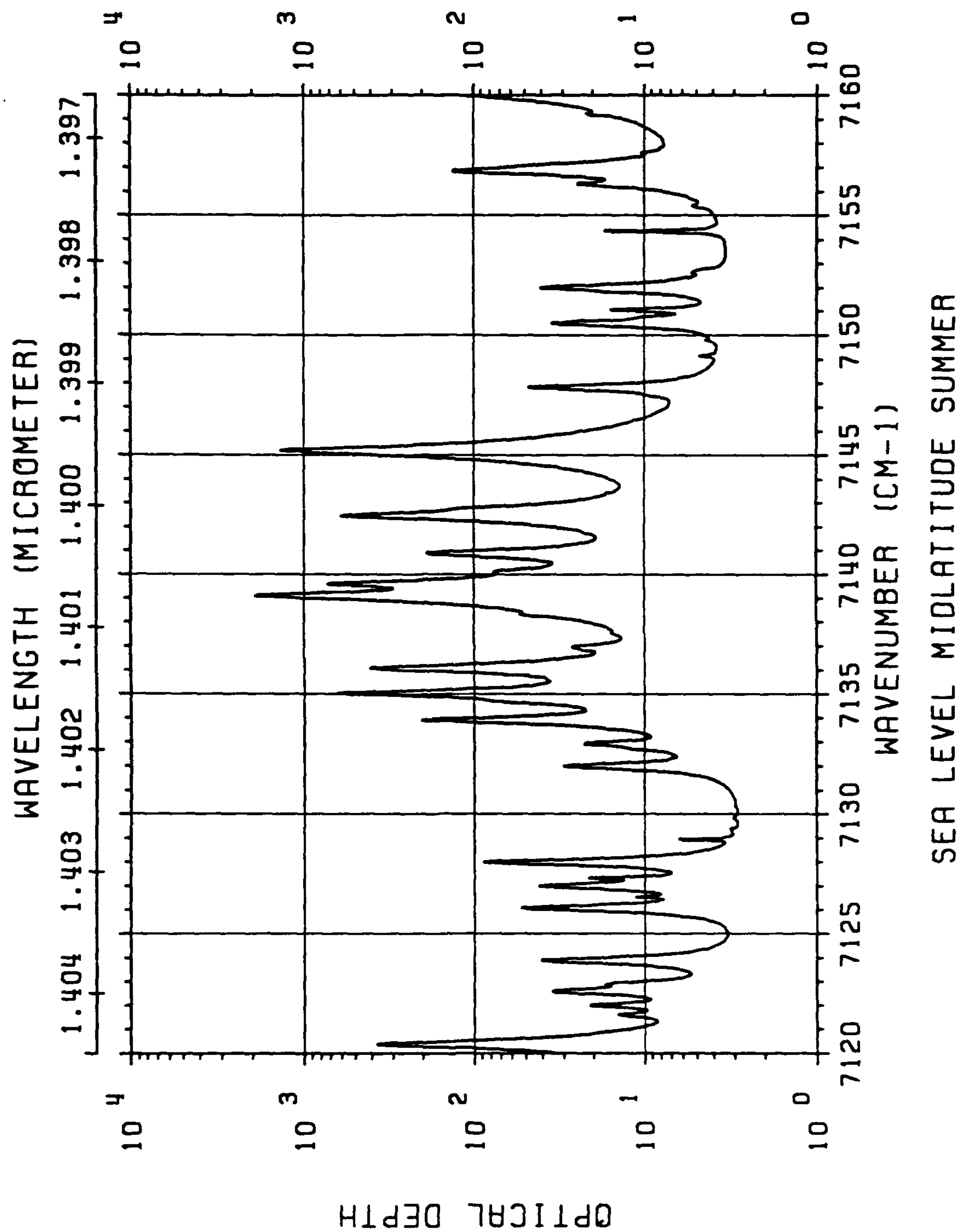


WAVELENGTH (MICROMETER)
1.428
1.427
1.426
1.425
1.424
1.423
1.422
1.421
OPTICAL DEPTH
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
7000
7005
7010
7015
7020
7025
7030
7035
7040
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

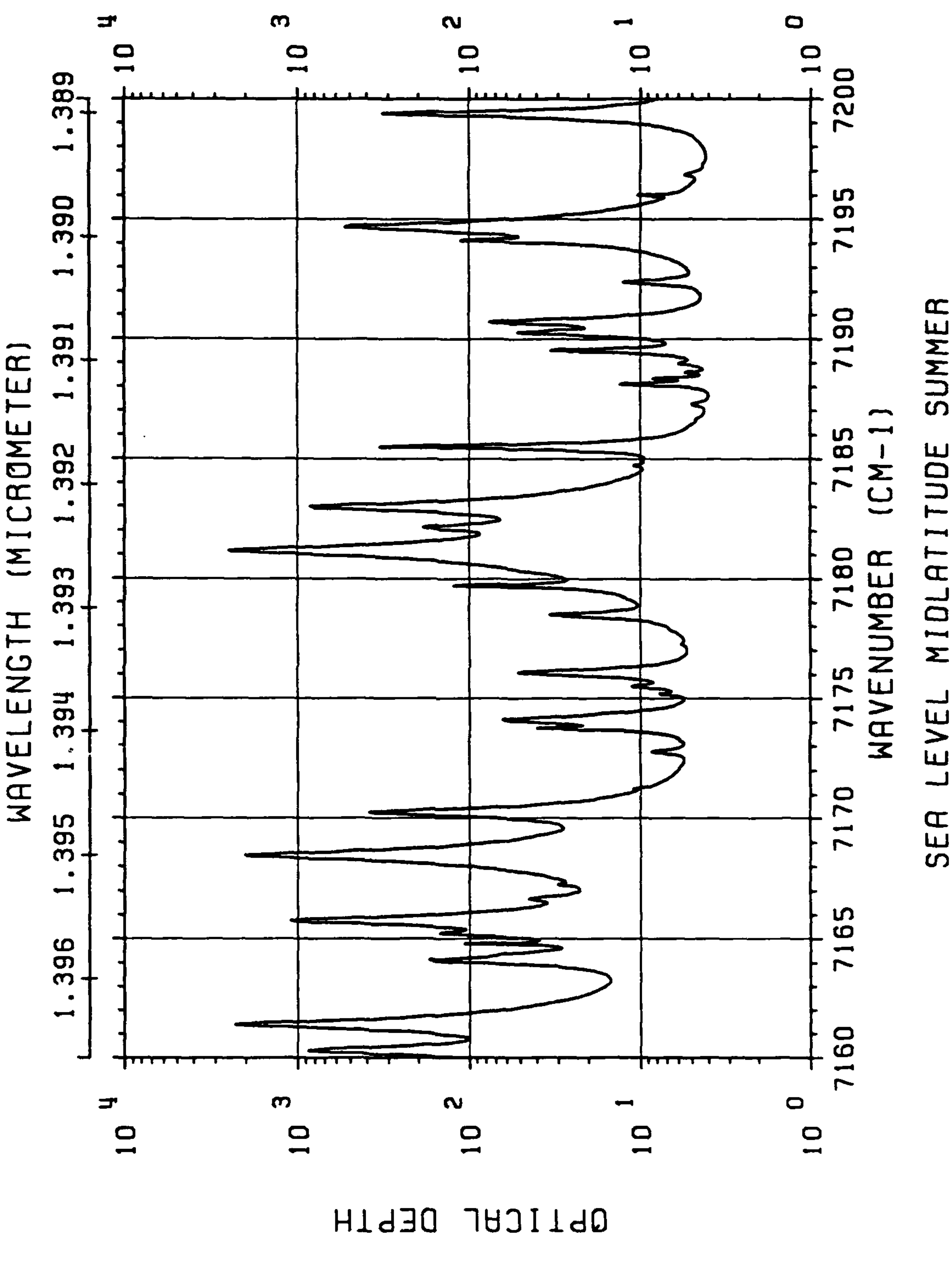

WAVELENGTH (MICROMETER)
1.420 1.419 1.418 1.417 1.416 1.415 1.414 1.413
WAVENUMBER (CM-1)
7040 7045 7050 7055 7060 7065 7070 7075 7080
OPTICAL DEPTH
10^4 10^3 10^2 10^1 10^0
SEA LEVEL MIDLATITUDE SUMMER



SEA LEVEL MIDLATITUDE SUMMER



WAVELENGTH (MICROMETER)
1.404
1.403
1.402
1.401
1.400
1.399
1.398
1.397
7120
7125
7130
7135
7140
7145
7150
7155
7160
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^0
10^1
10^2
10^3
10^4


WAVELENGTH (MICROMETER)
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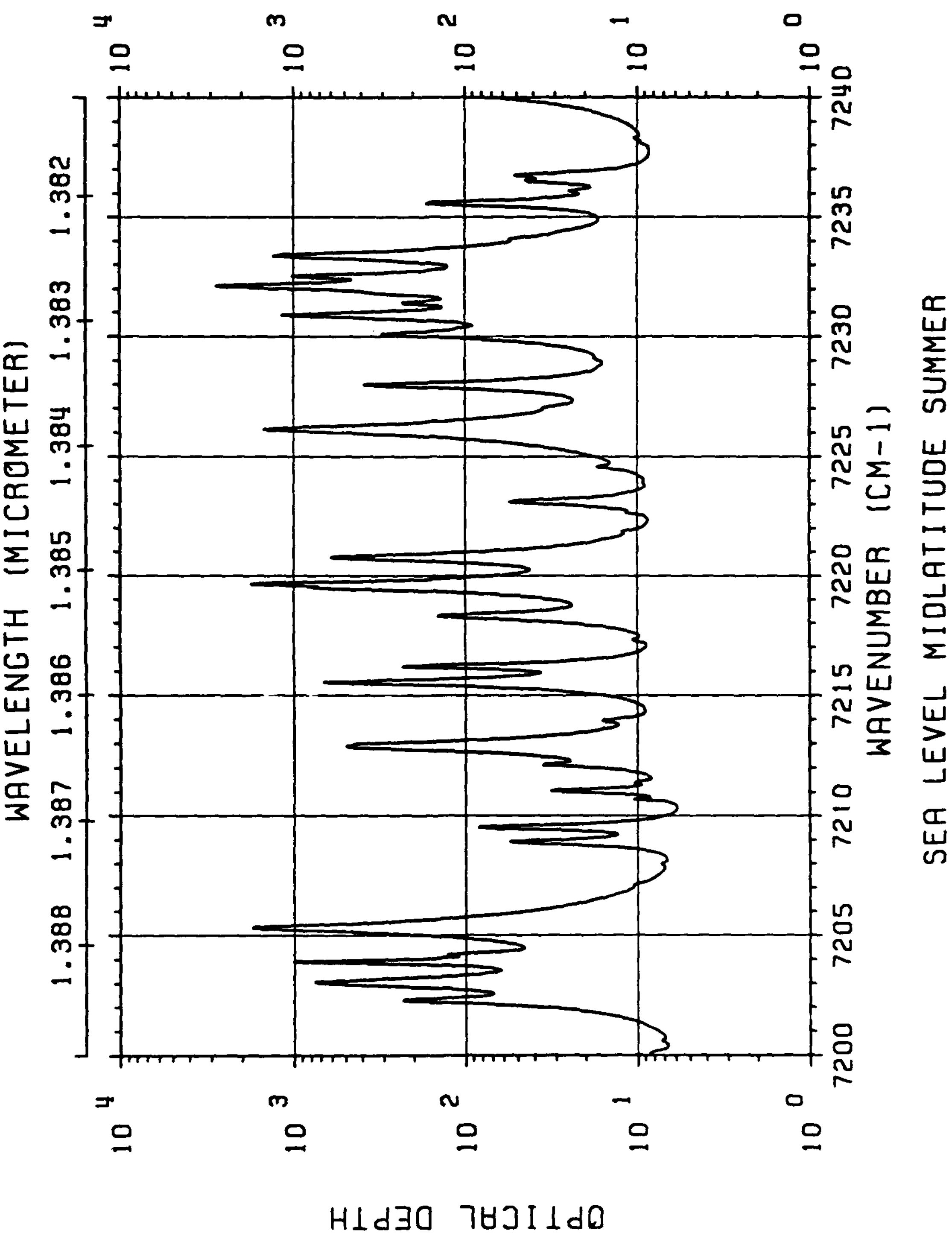
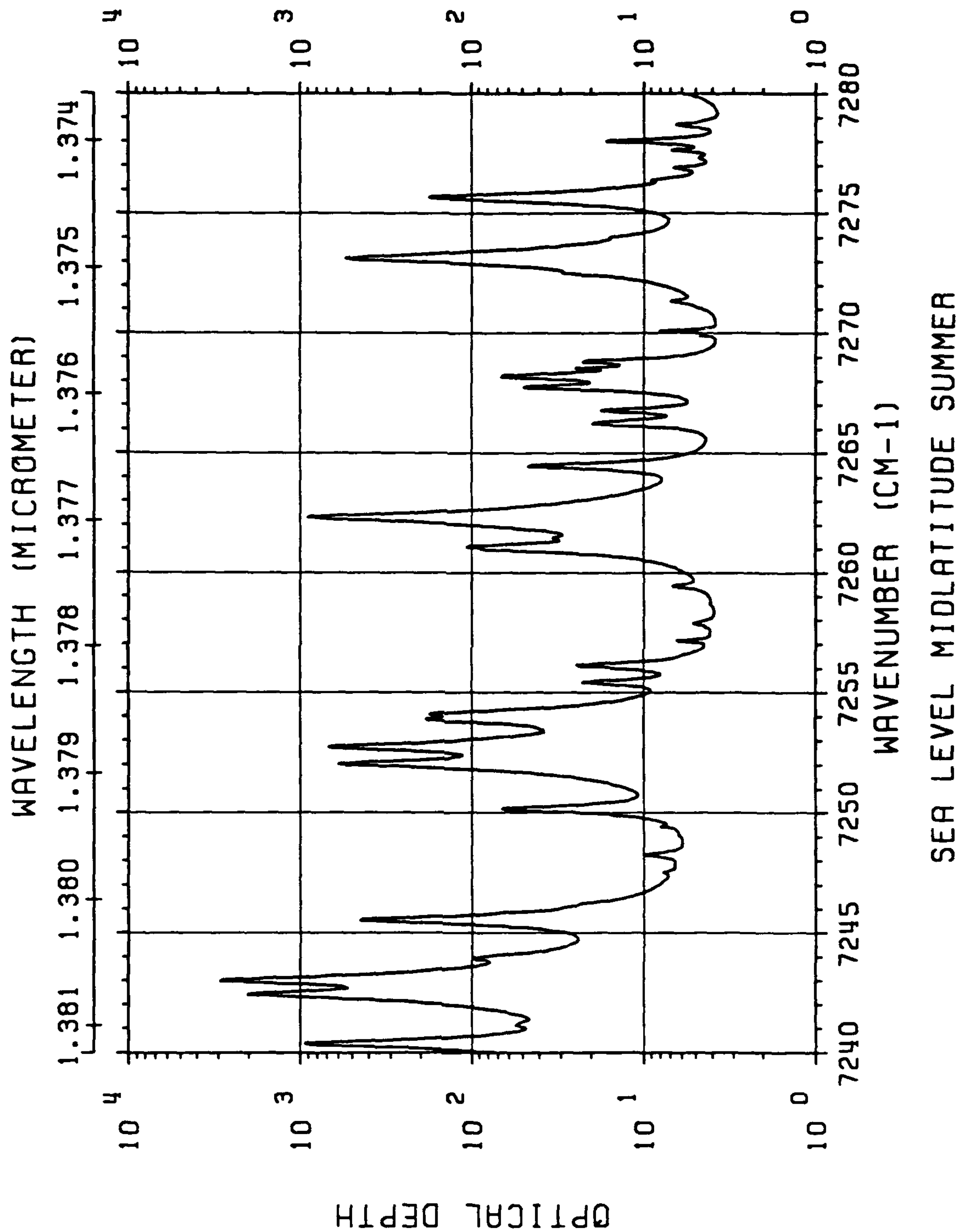
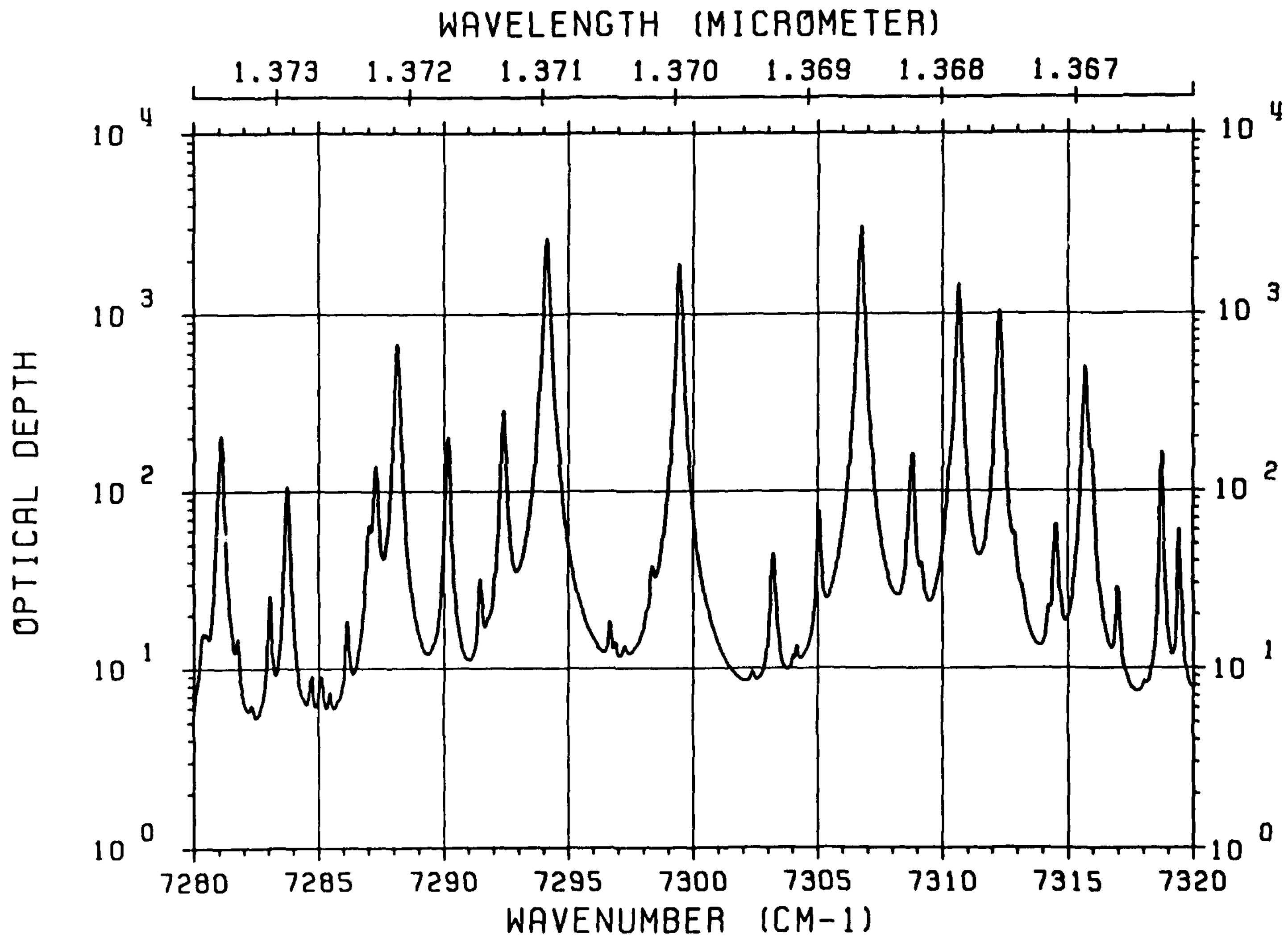
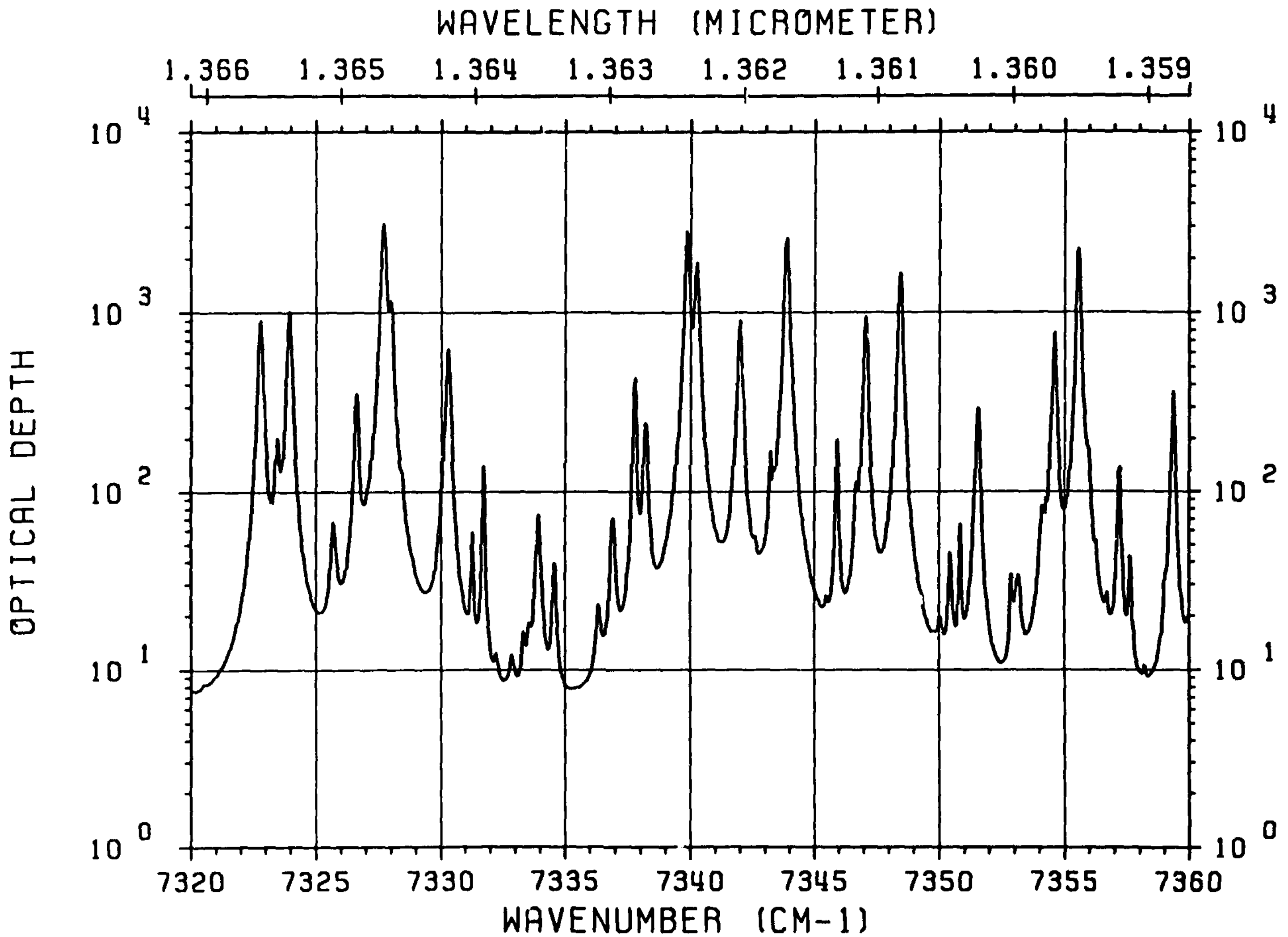
1.390
1.391
1.392
1.393
1.394
1.395
1.396
7160
7165
7170
7175
7180
7185
7190
7195
7200
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^0
10^1
10^2
10^3
10^4


WAVELENGTH (MICROMETER)
1.382
1.383
1.384
1.385
1.386
1.387
1.388
OPTICAL DEPTH
10^4
10^3
10^2
10^1
10^0
7200
7205
7210
7215
7220
7225
7230
7235
7240
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

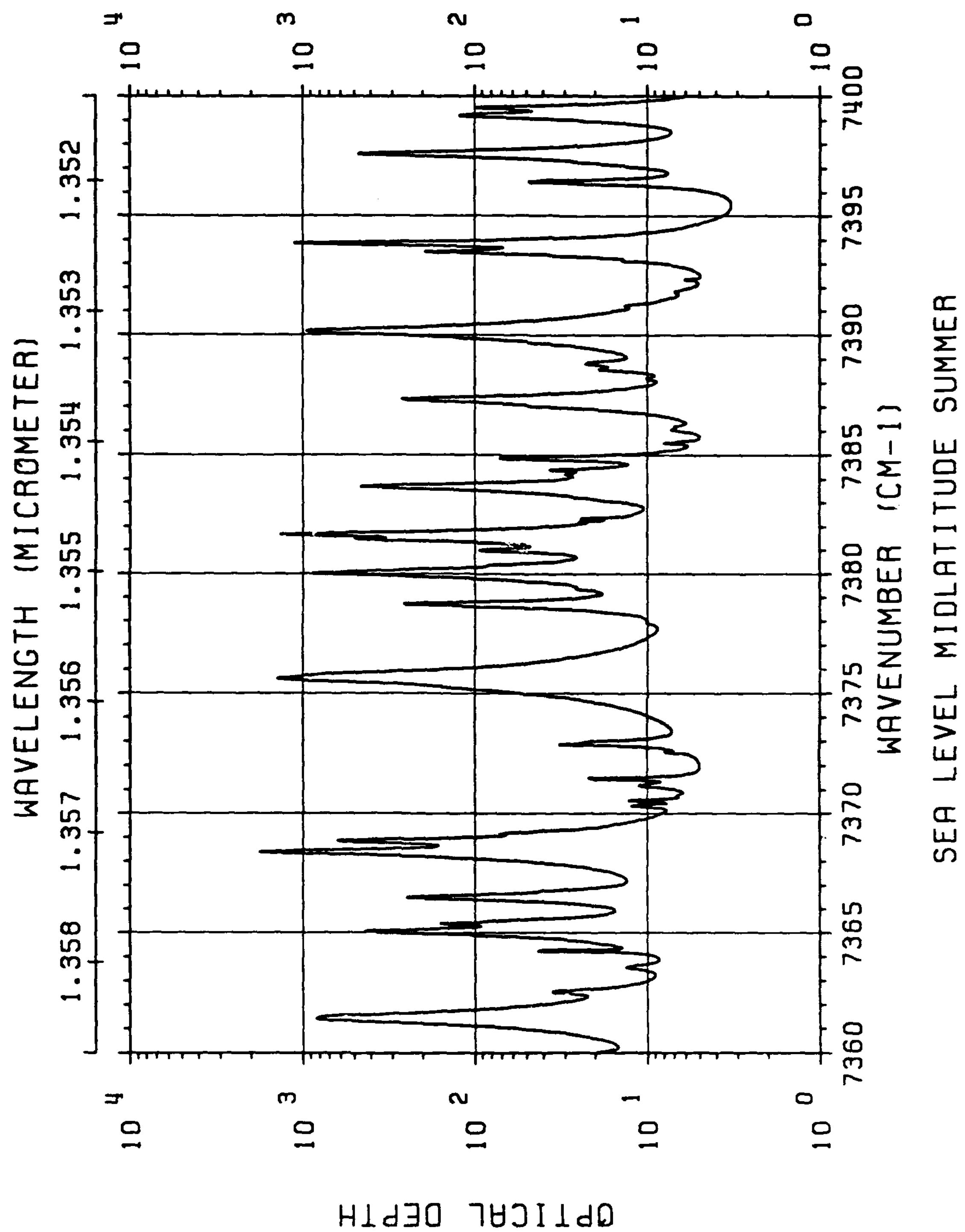

WAVELENGTH (MICROMETER)
1.381
1.380
1.379
1.378
1.377
1.376
1.375
1.374
OPTICAL DEPTH
10^0
10^1
10^2
10^3
10^4
7240
7245
7250
7255
7260
7265
7270
7275
7280
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

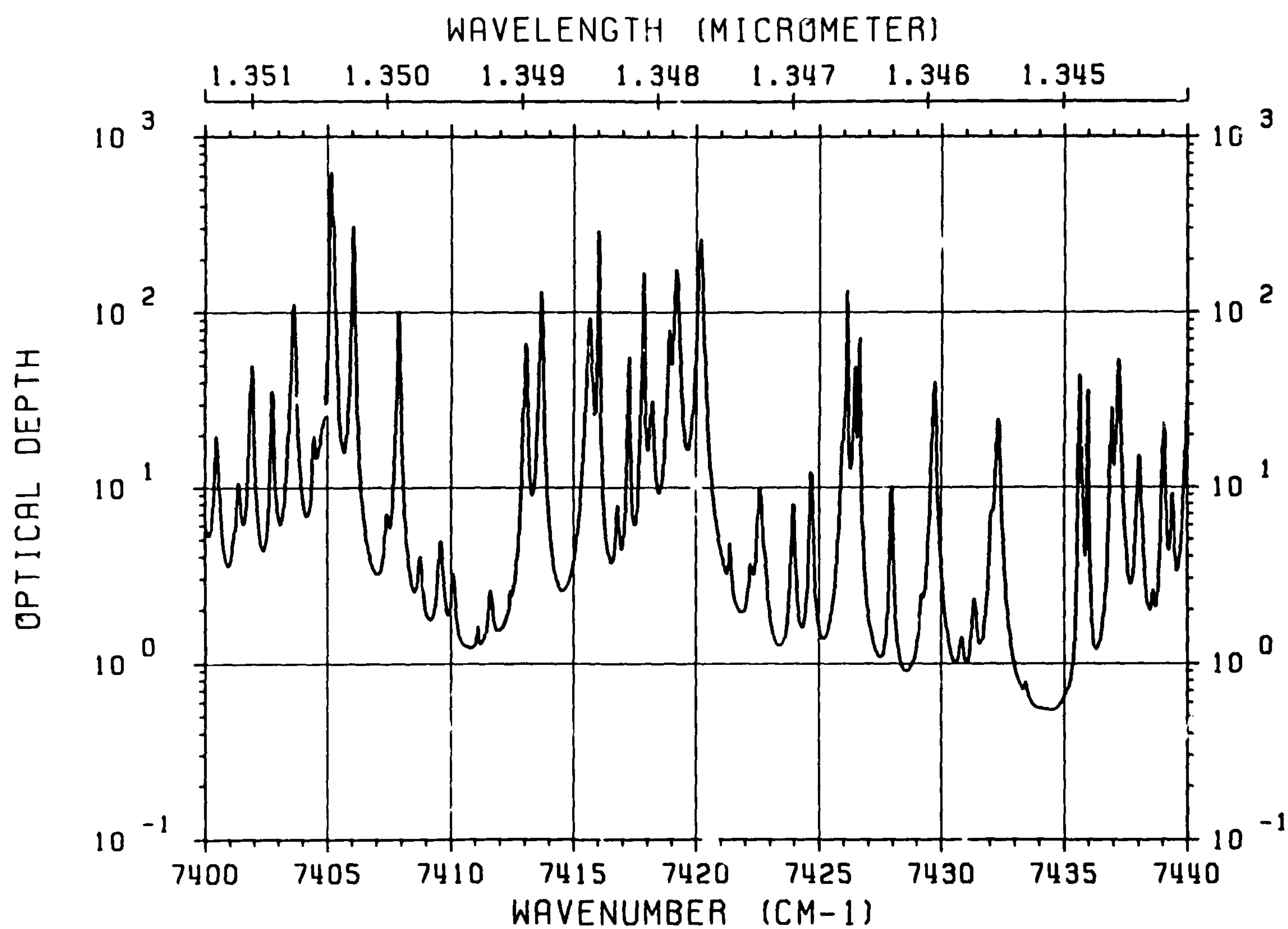


SEA LEVEL MIDLATITUDE SUMMER

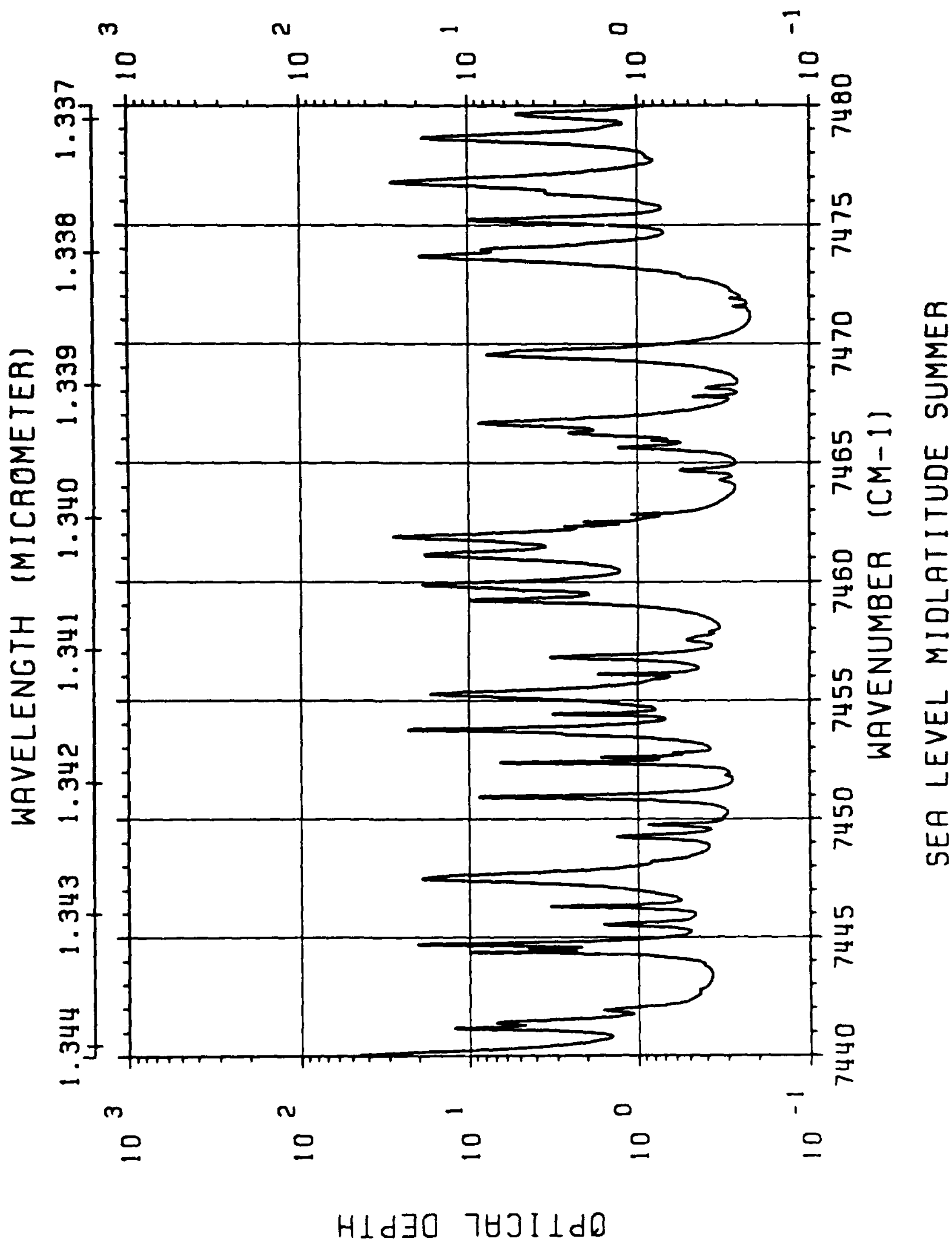


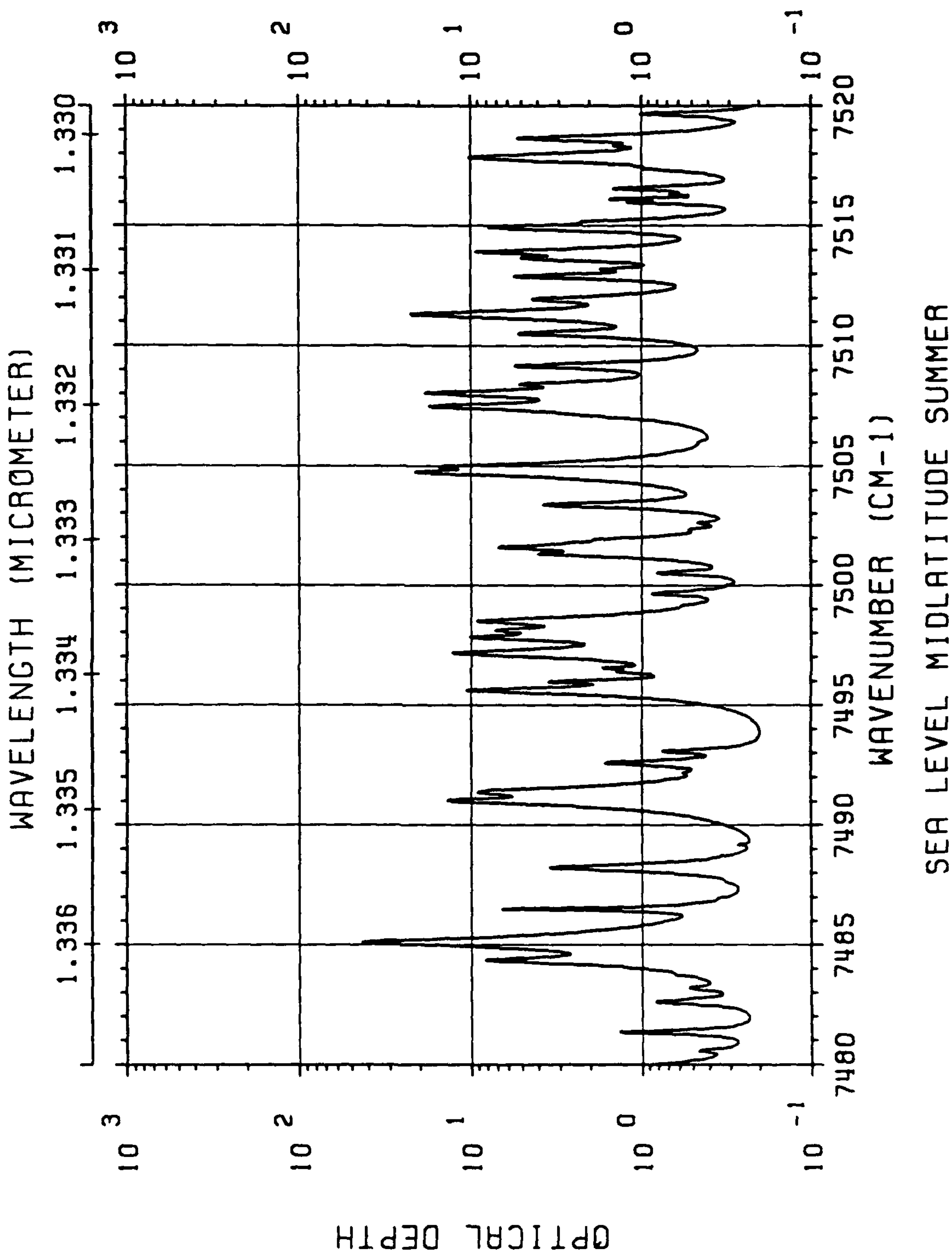
SEA LEVEL MIDLATITUDE SUMMER

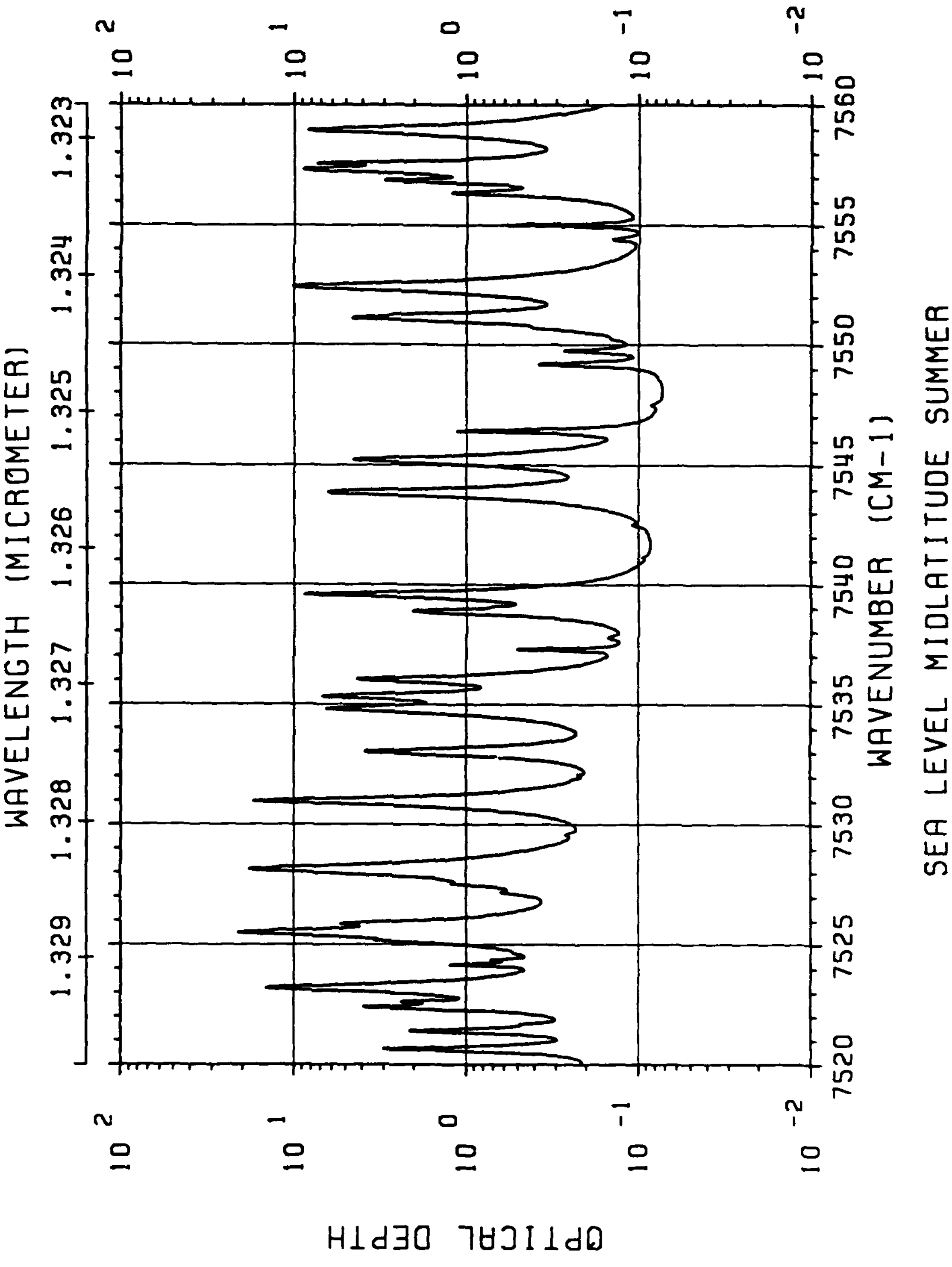

WAVELENGTH (MICRØMETER)
1.352
1.353
1.354
1.355
1.356
1.357
1.358
OPTICAL DEPTH
10^0
10^1
10^2
10^3
10^4
7360
7365
7370
7375
7380
7385
7390
7395
7400
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

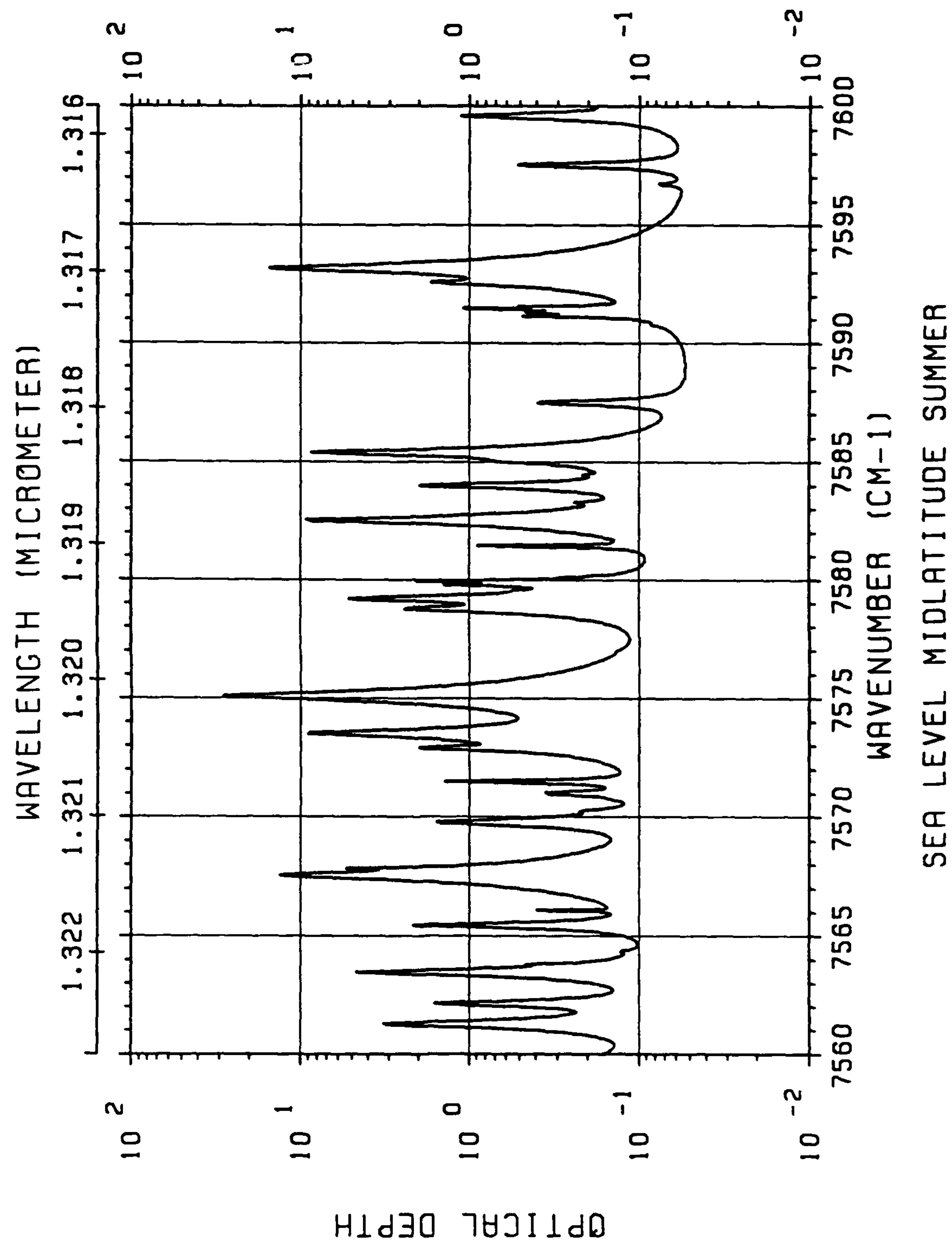


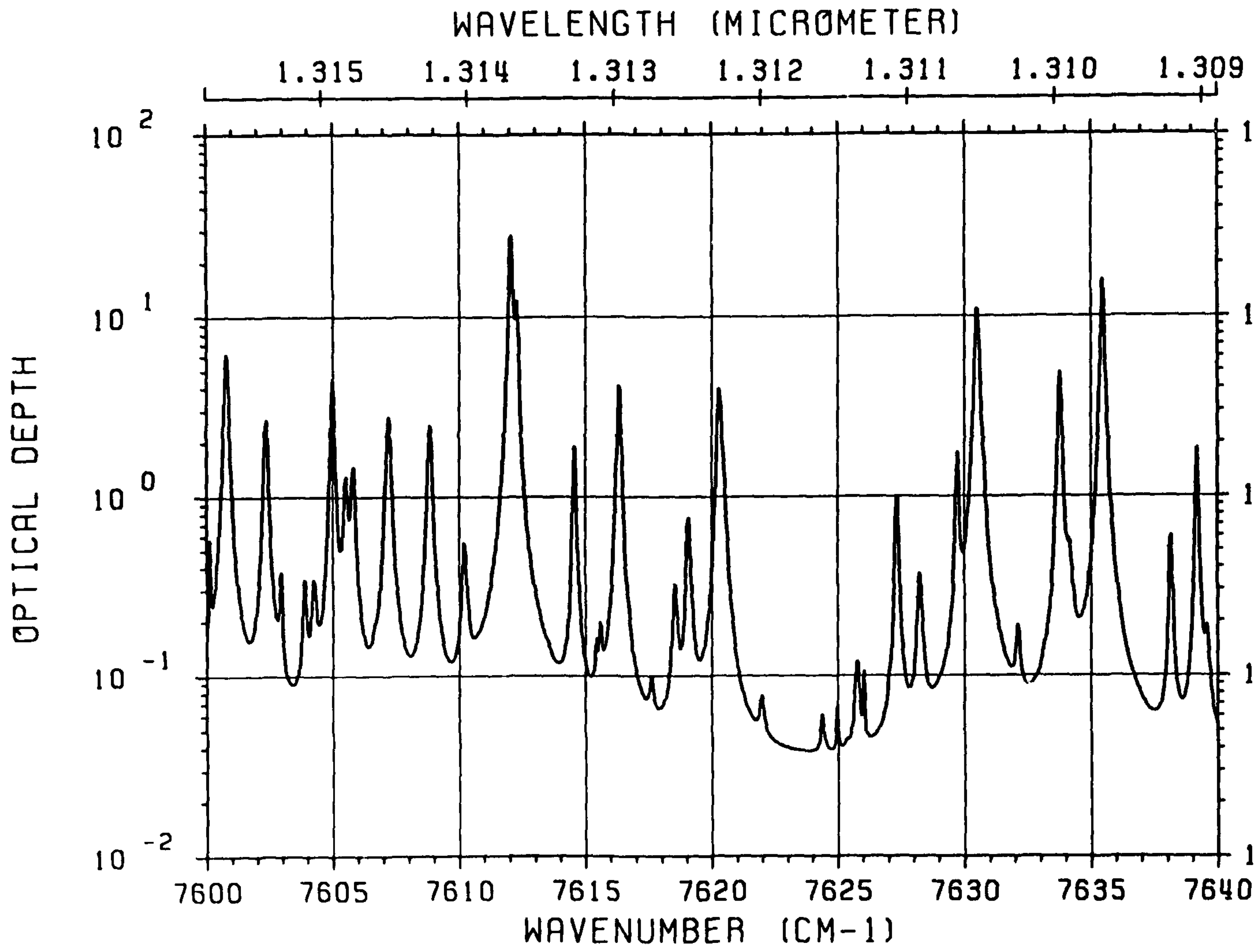
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.337
1.338
1.339
1.340
1.341
1.342
1.343
1.344
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
OPTICAL DEPTH
7440
7445
7450
7455
7460
7465
7470
7475
7480
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

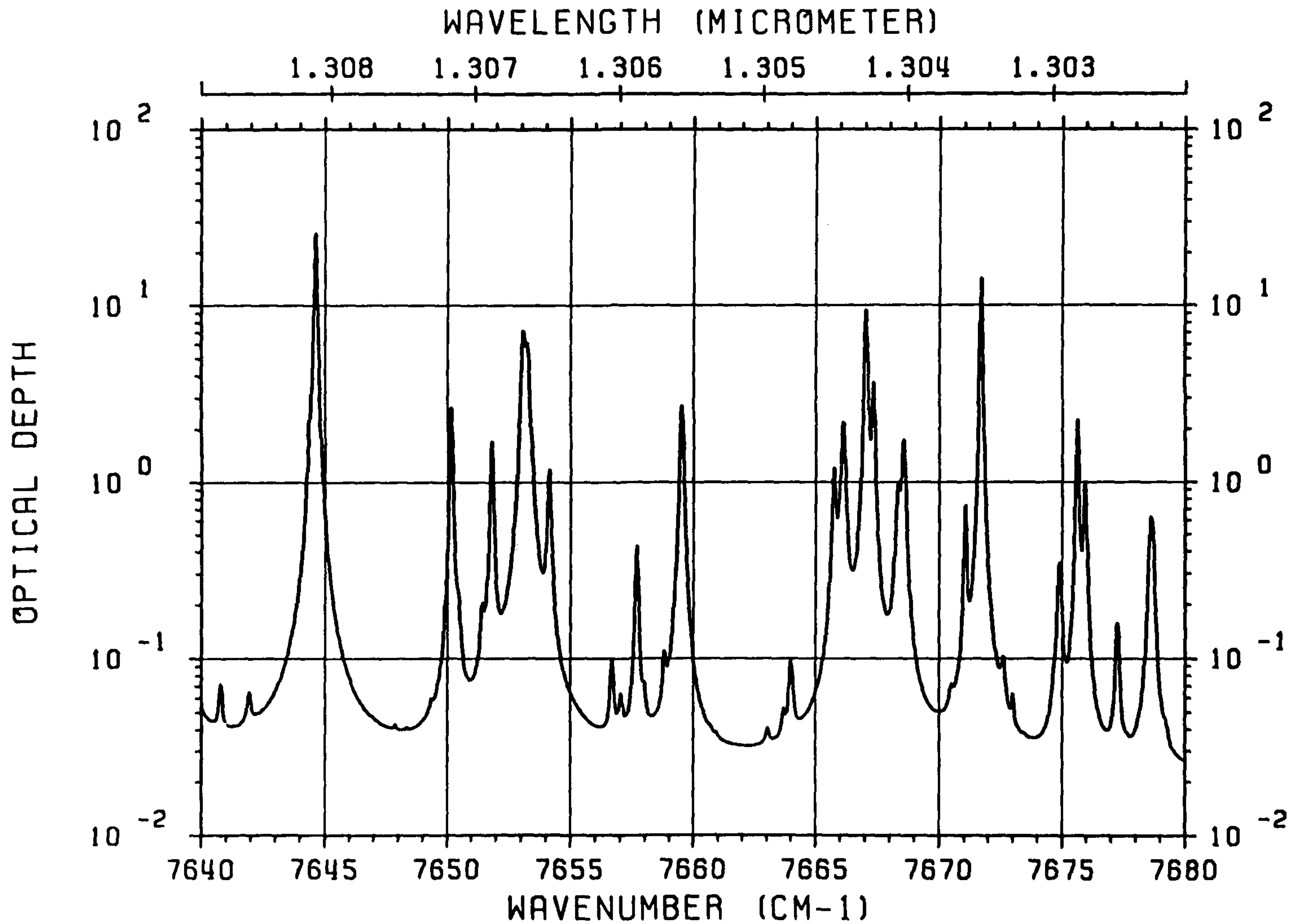

WAVELENGTH (MICROMETER)
1.330
1.331
1.332
1.333
1.334
1.335
1.336
10^3
10^2
10^1
10^0
10^-1
OPTICAL DEPTH
7480
7485
7490
7495
7500
7505
7510
7515
7520
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.323
1.324
1.325
1.326
1.327
1.328
1.329
OPTICAL DEPTH
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
7520
7525
7530
7535
7540
7545
7550
7555
7560
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

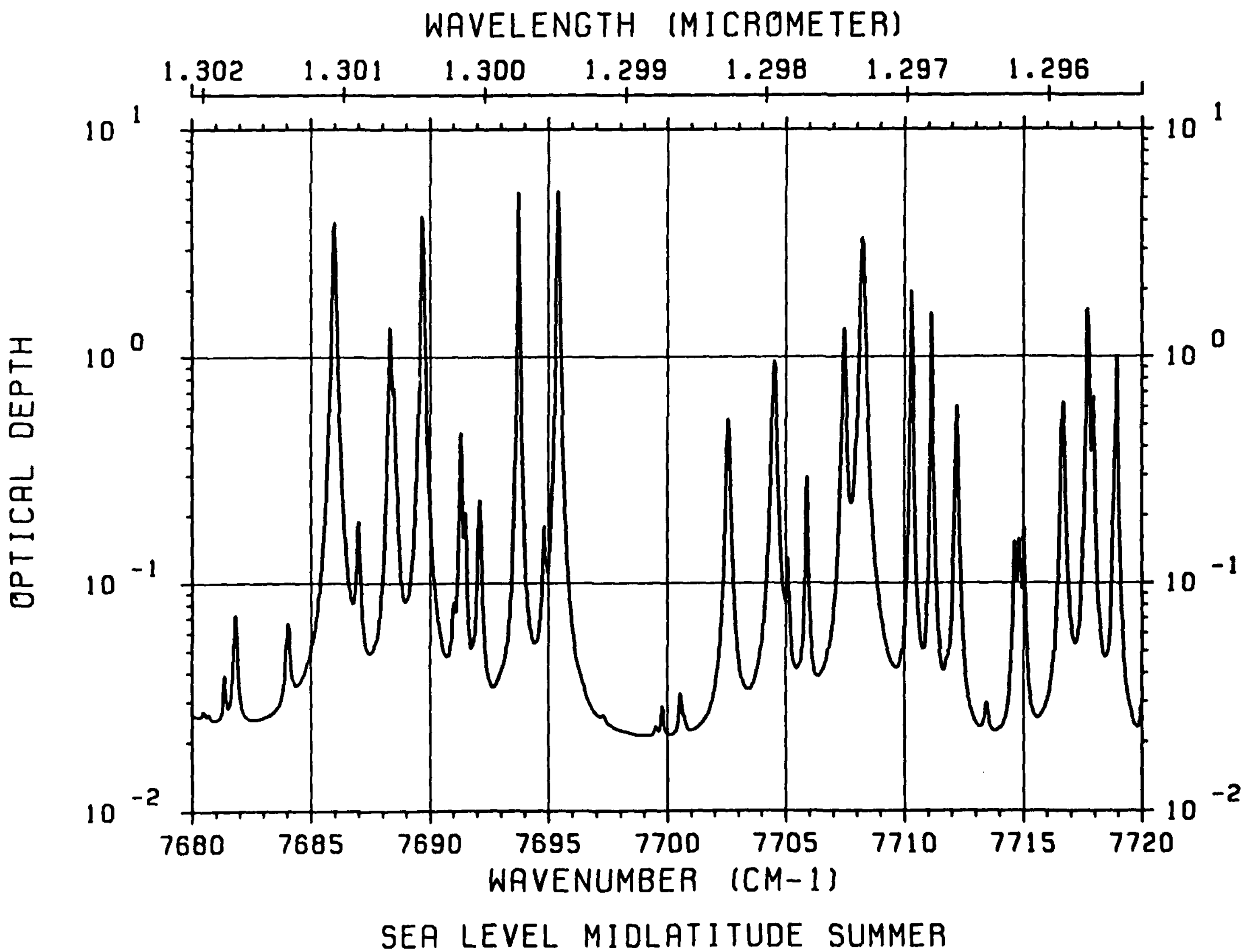

WAVELENGTH (MICROMETER)
1.316
1.317
1.318
1.319
1.320
1.321
1.322
10 2
10 1
10 0
10 -1
10 -2
7560
7565
7570
7575
7580
7585
7590
7595
7600
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH



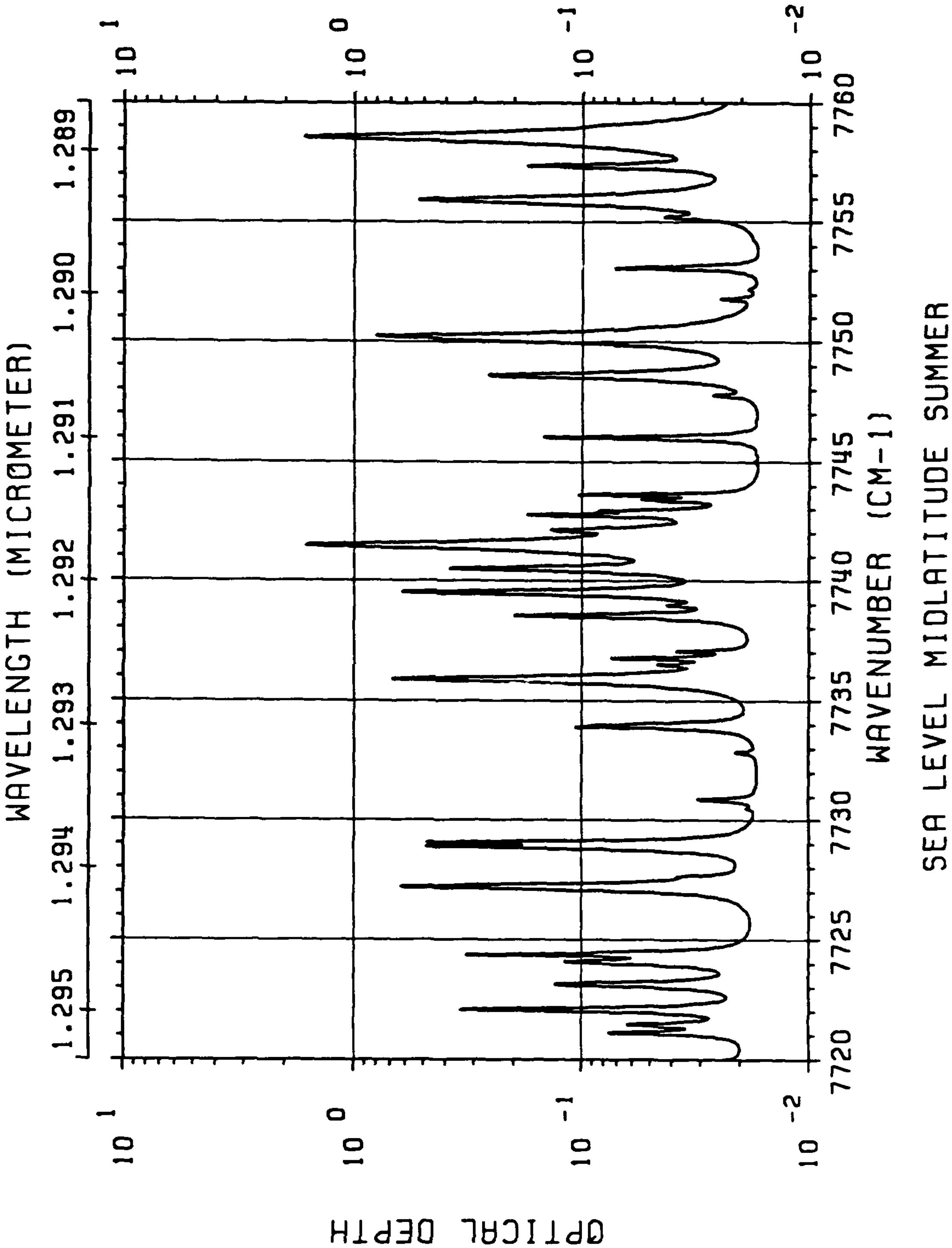
SEA LEVEL MIDLATITUDE SUMMER

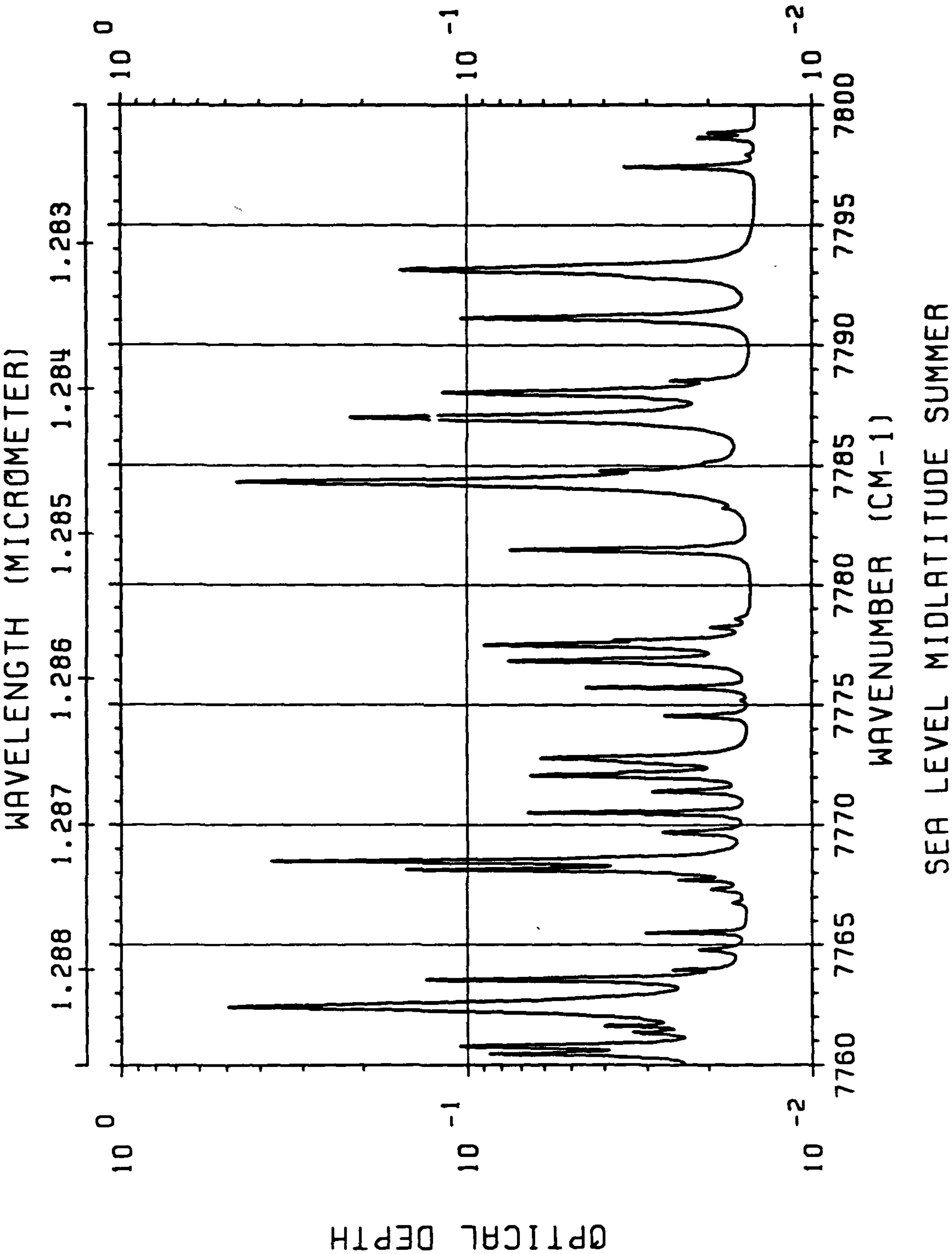


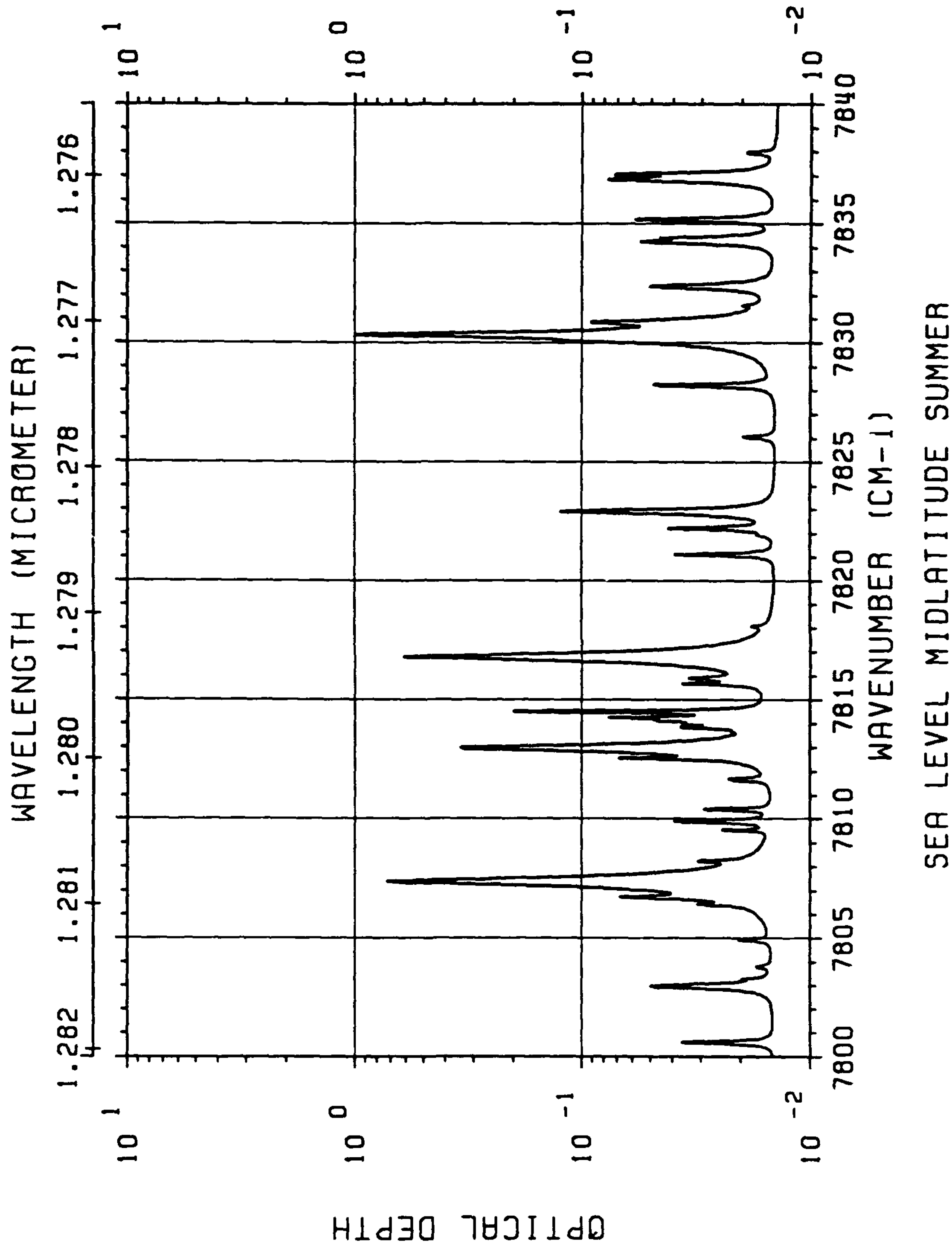
SEA LEVEL MIDLATITUDE SUMMER



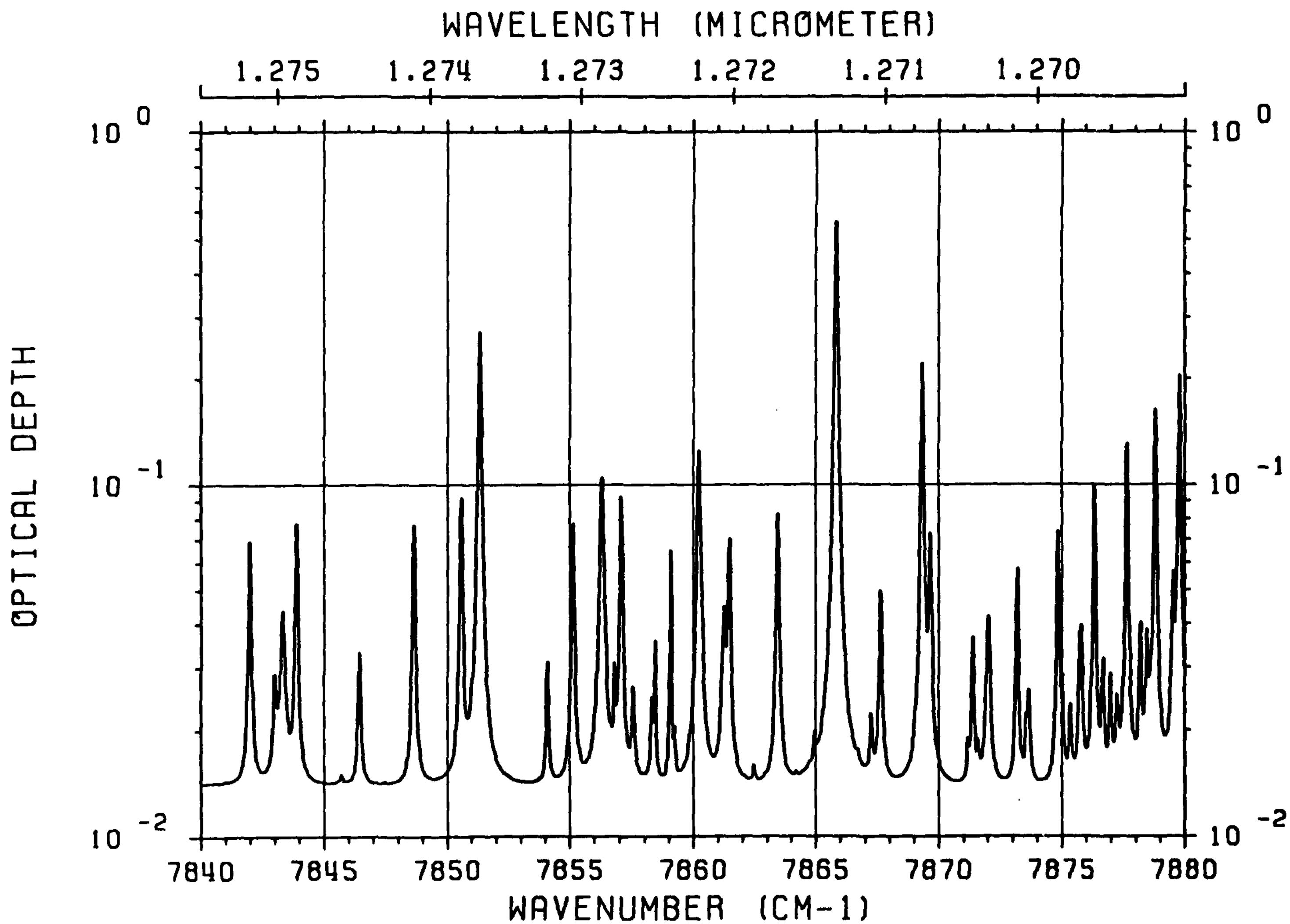
WAVELENGTH (MICROMETER)
1.302
1.301
1.300
1.299
1.298
1.297
1.296
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}
7680
7685
7690
7695
7700
7705
7710
7715
7720
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.289
1.290
1.291
1.292
1.293
1.294
1.295
7720
7725
7730
7735
7740
7745
7750
7755
7760
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}

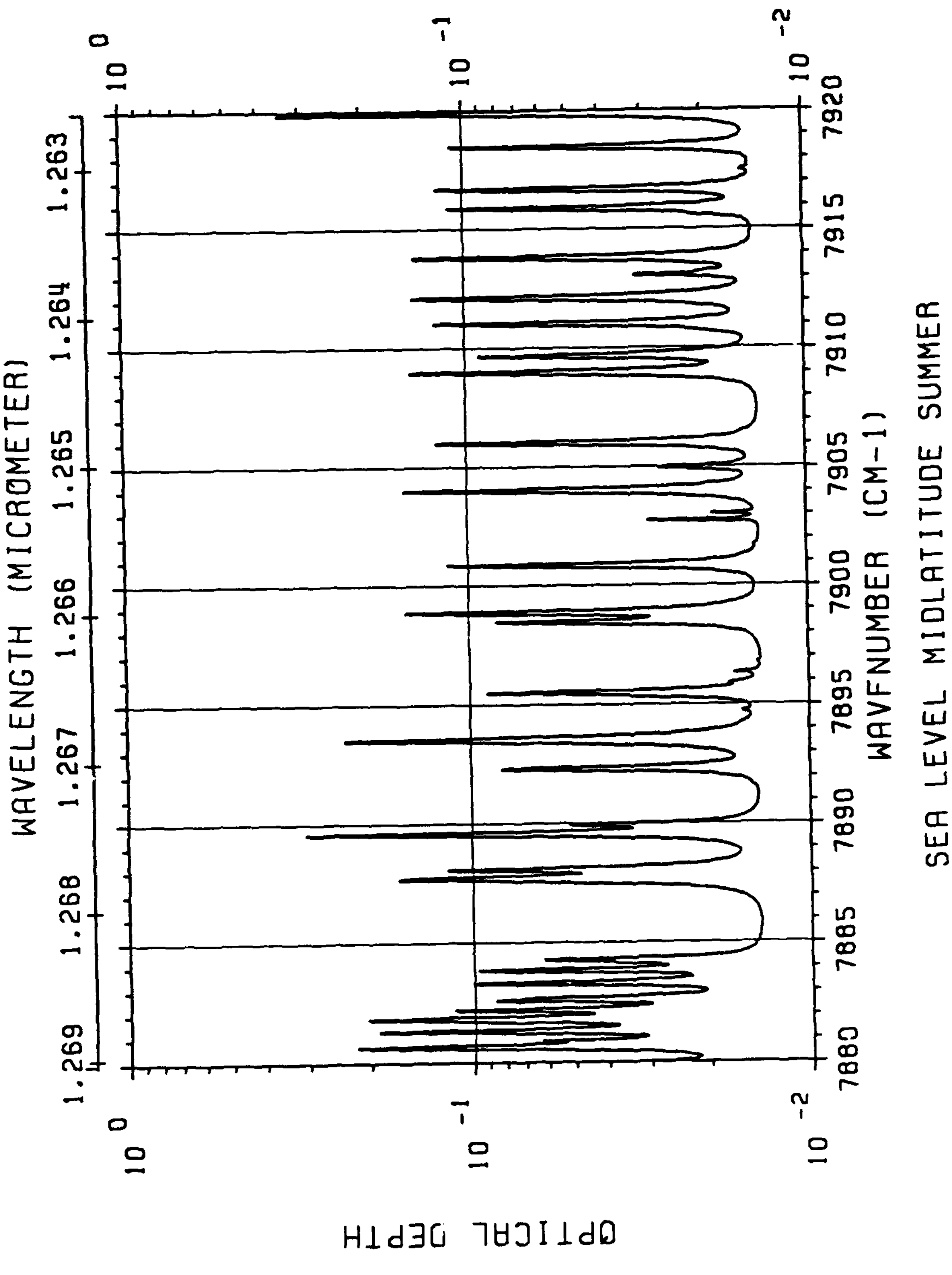

WAVELENGTH (MICROMETER)
1.288
1.287
1.286
1.285
1.284
1.283
10^0
10^-1
10^-2
7760
7765
7770
7775
7780
7785
7790
7795
7800
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH



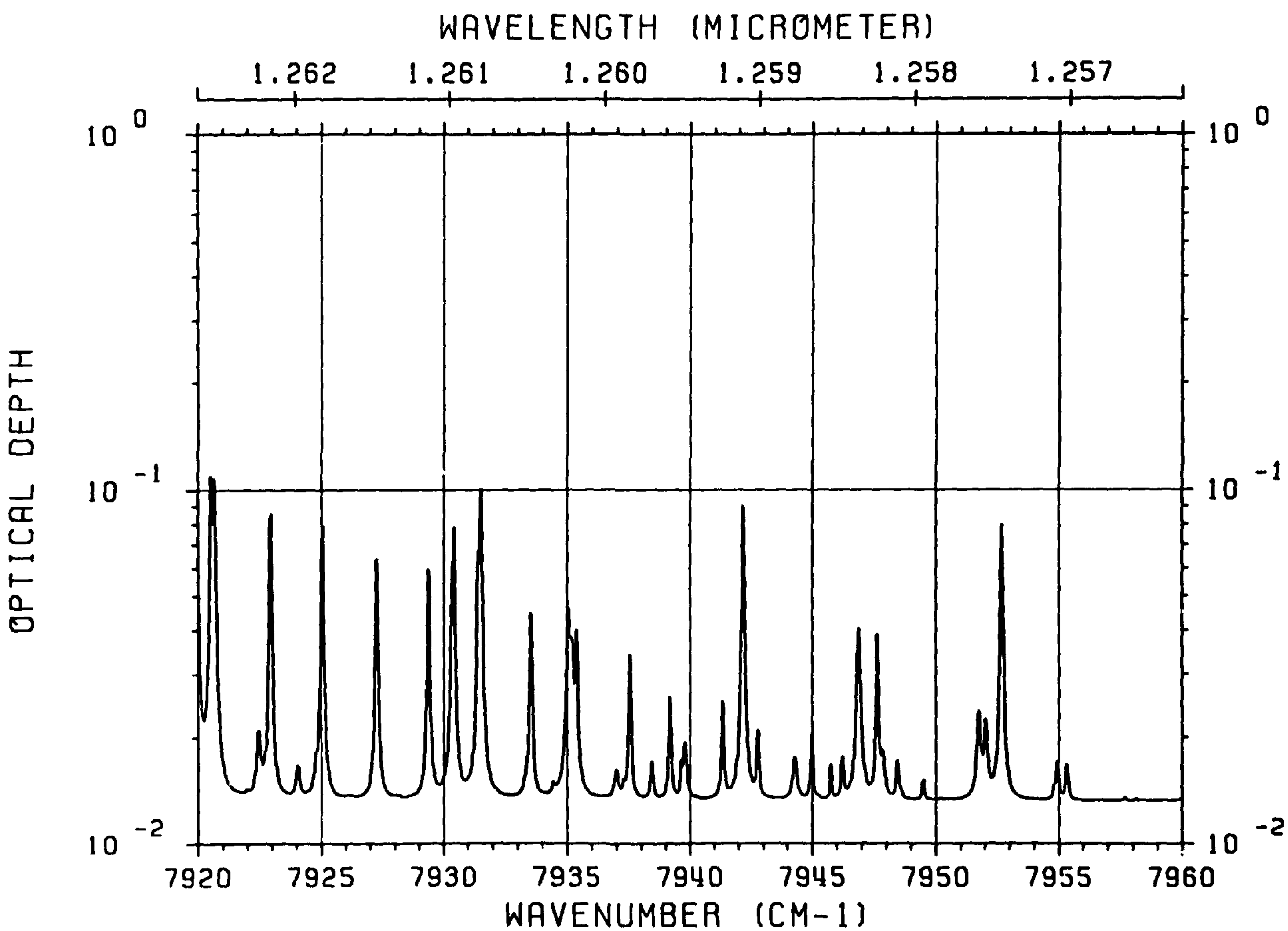
WAVELENGTH (MICROMETER)
1.276
1.277
1.278
1.279
1.280
1.281
1.282
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}
7800
7805
7810
7815
7820
7825
7830
7835
7840
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



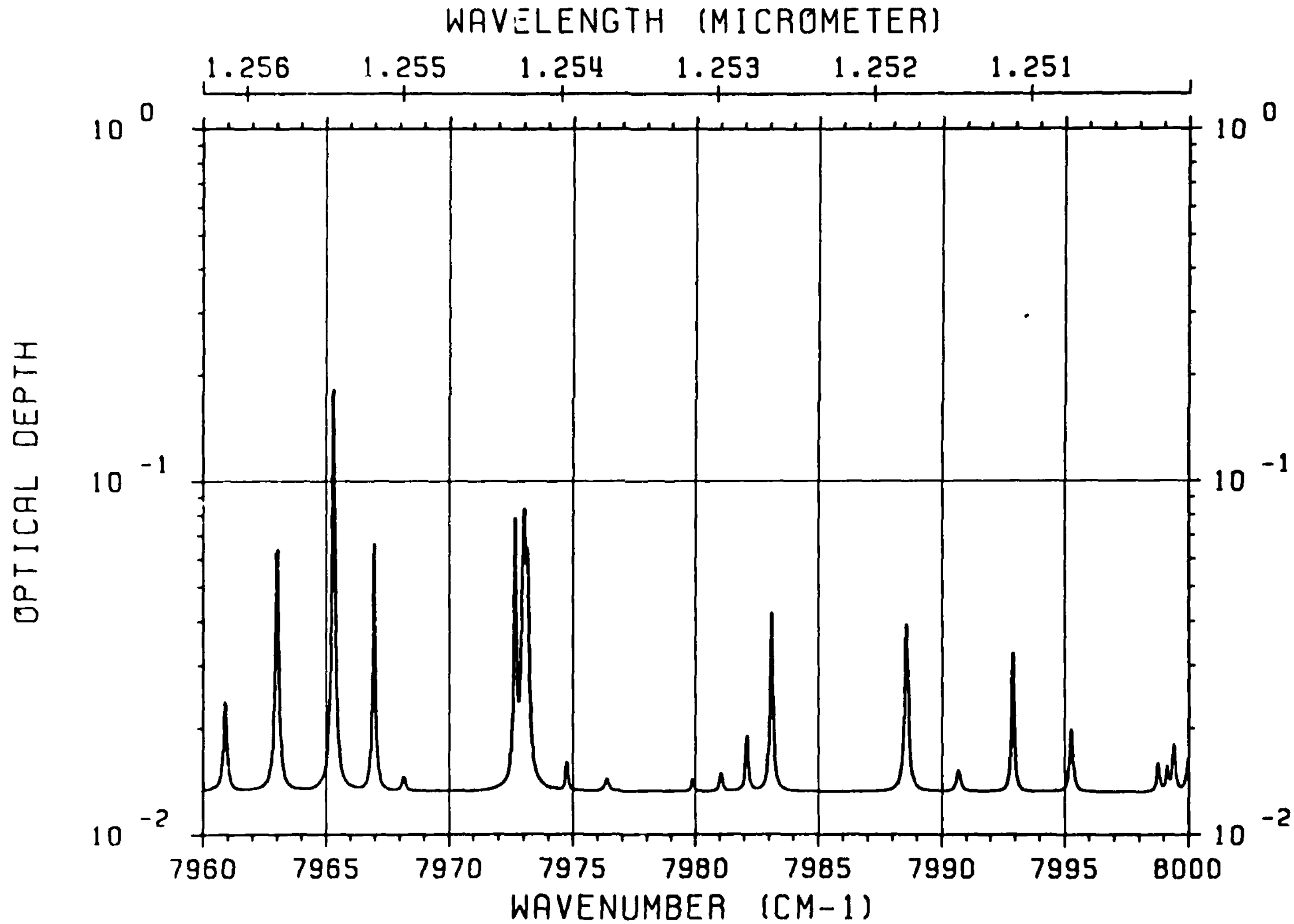
SEA LEVEL MIDLATITUDE SUMMER



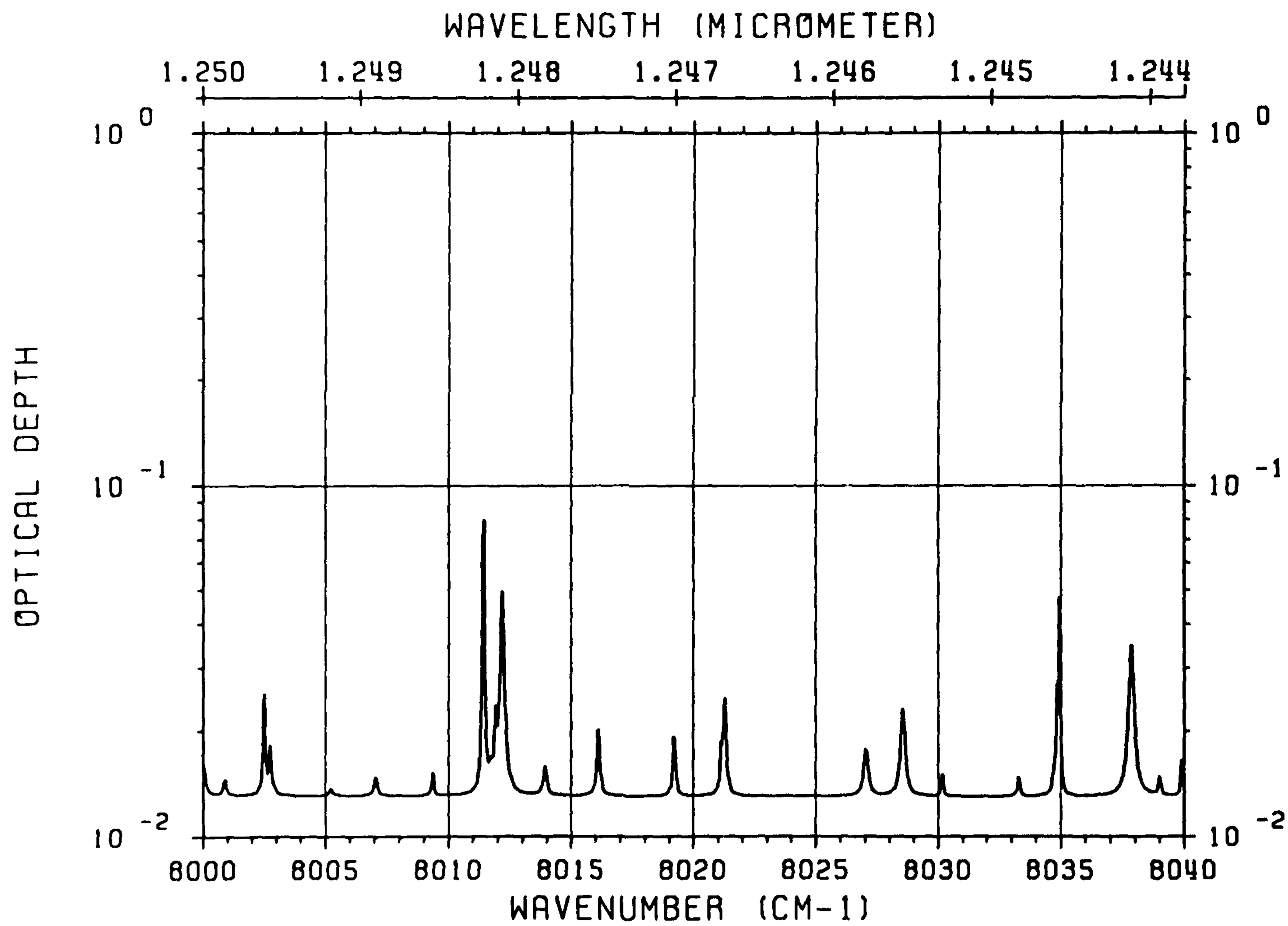
WAVELENGTH (MICROMETER)
1.269
1.268
1.267
1.266
1.265
1.264
1.263
10^0
10^-1
10^-2
7880
7885
7890
7895
7900
7905
7910
7915
7920
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH



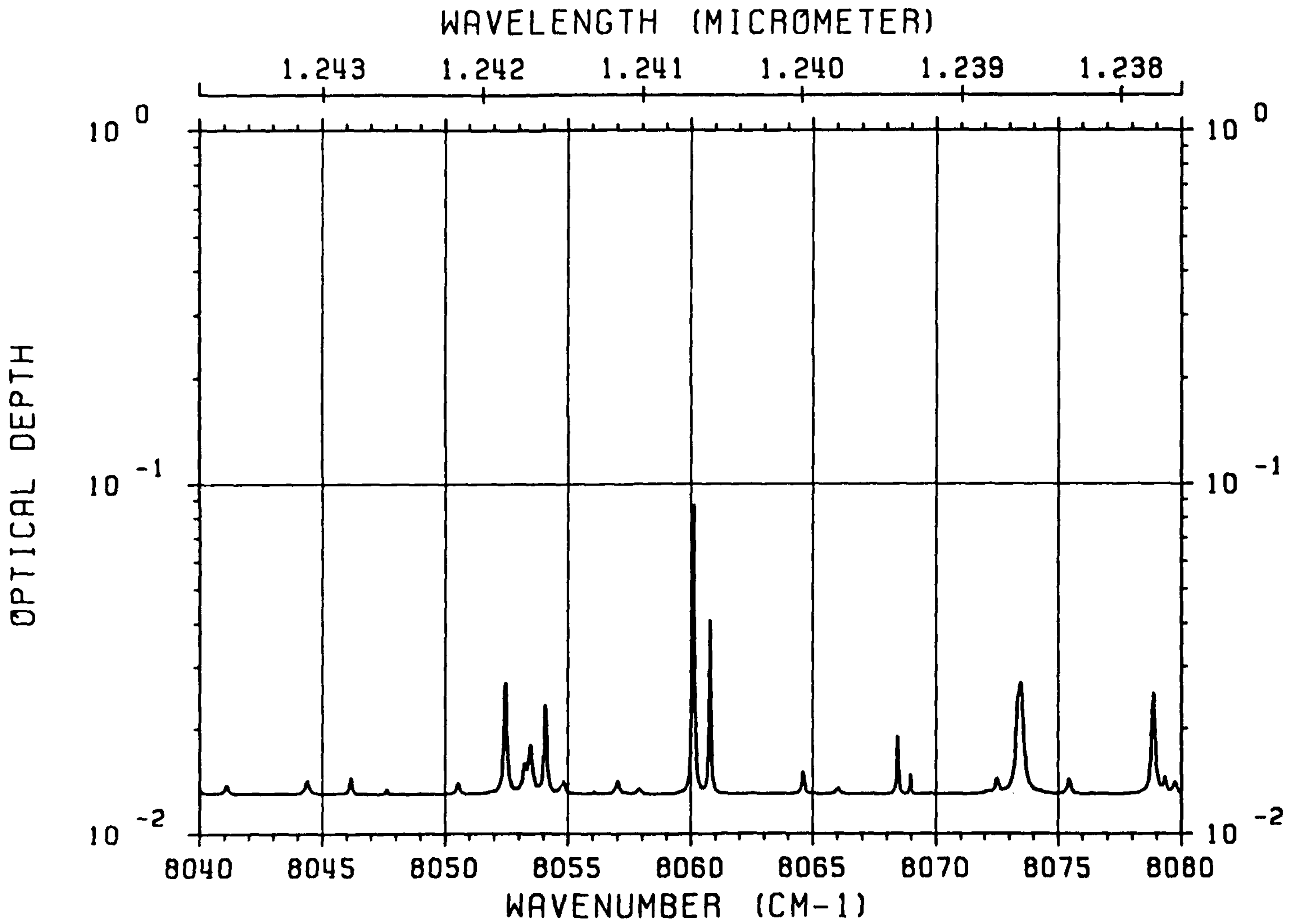
SEA LEVEL MIDLATITUDE SUMMER



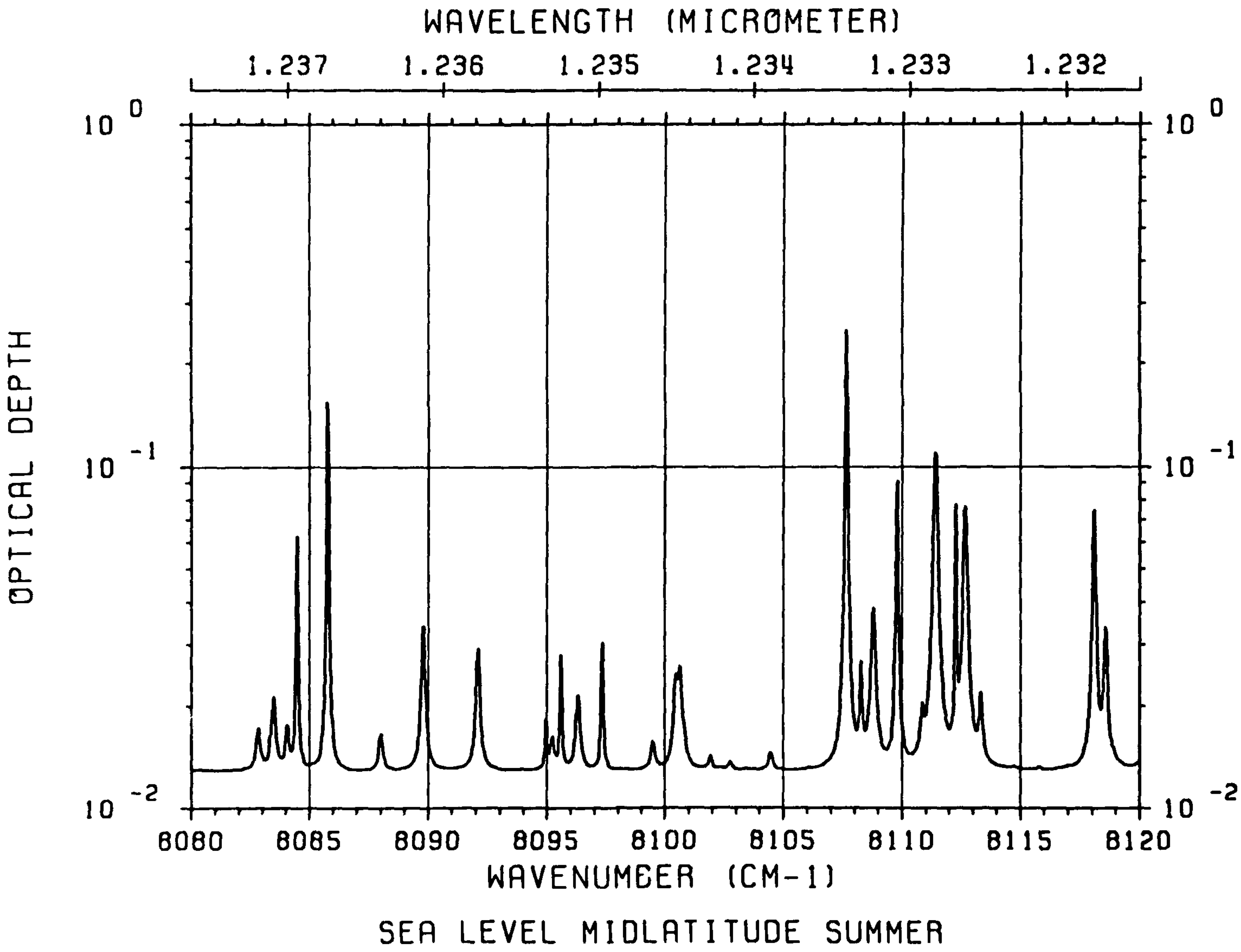
SEA LEVEL MIDLATITUDE SUMMER

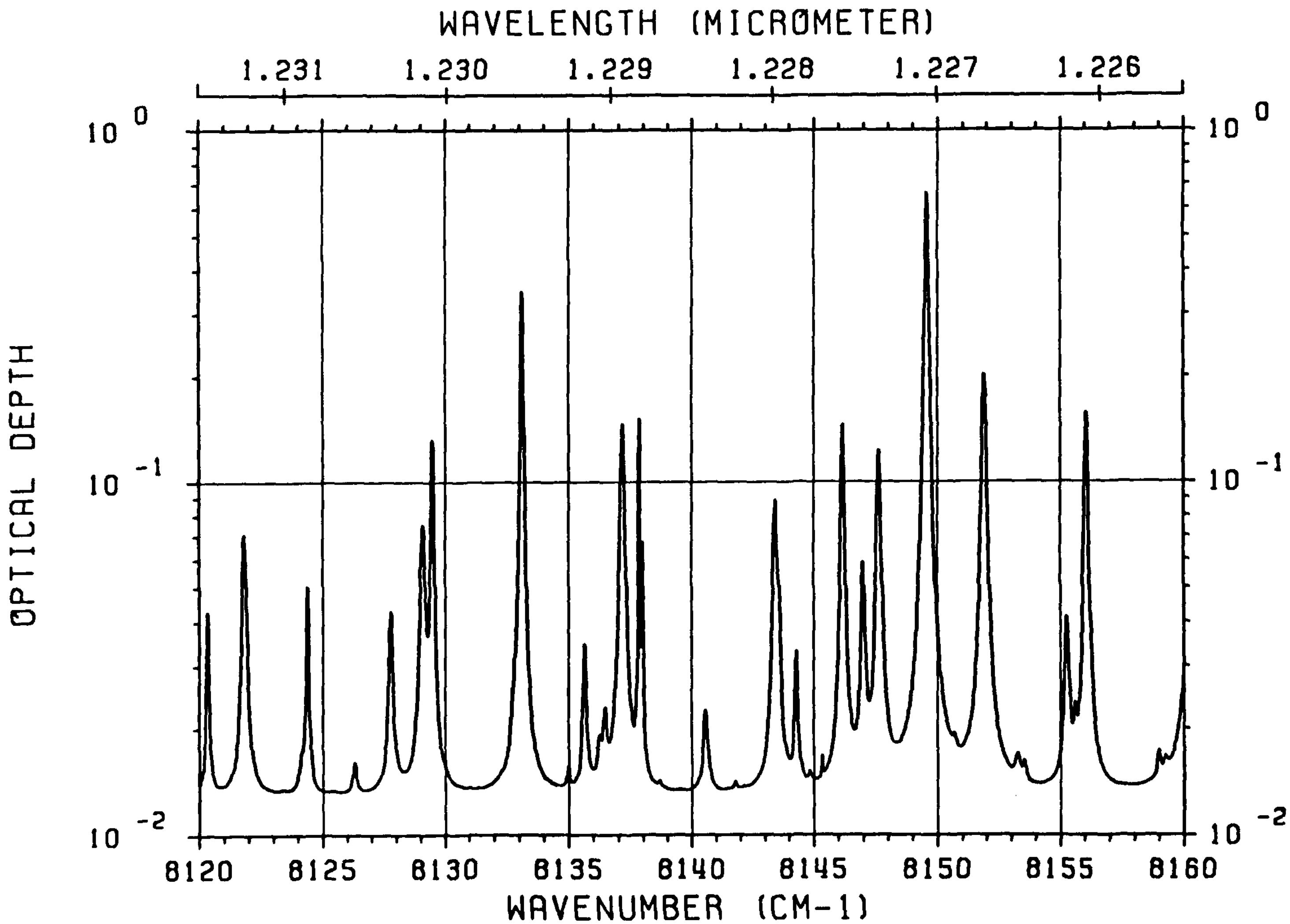


SEA LEVEL MIDLATITUDE SUMMER

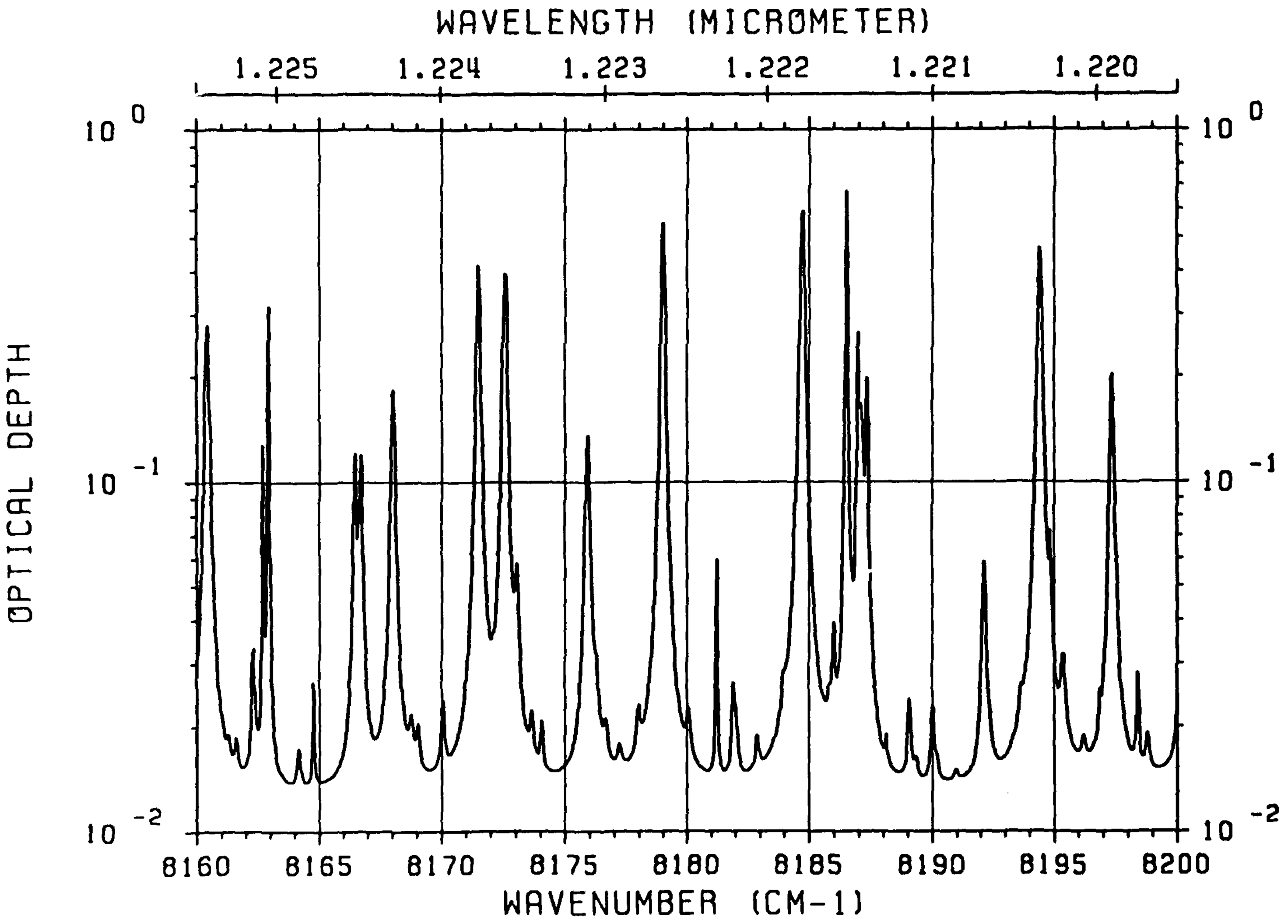


SEA LEVEL MIDLATITUDE SUMMER

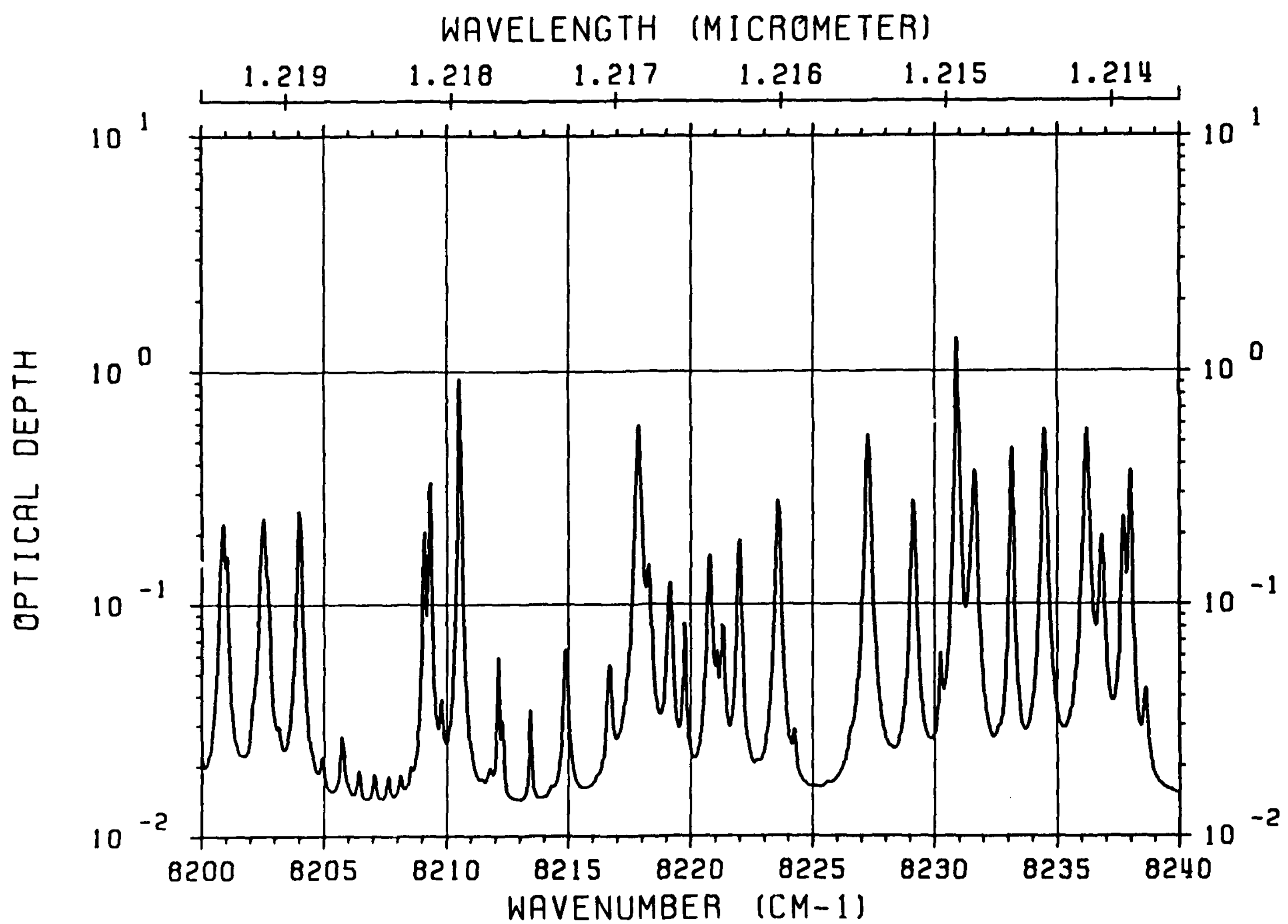

WAVELENGTH (MICROMETER)
1.237
1.236
1.235
1.234
1.233
1.232
OPTICAL DEPTH
10^{0}
10^{-1}
10^{-2}
8080
8085
8090
8095
8100
8105
8110
8115
8120
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



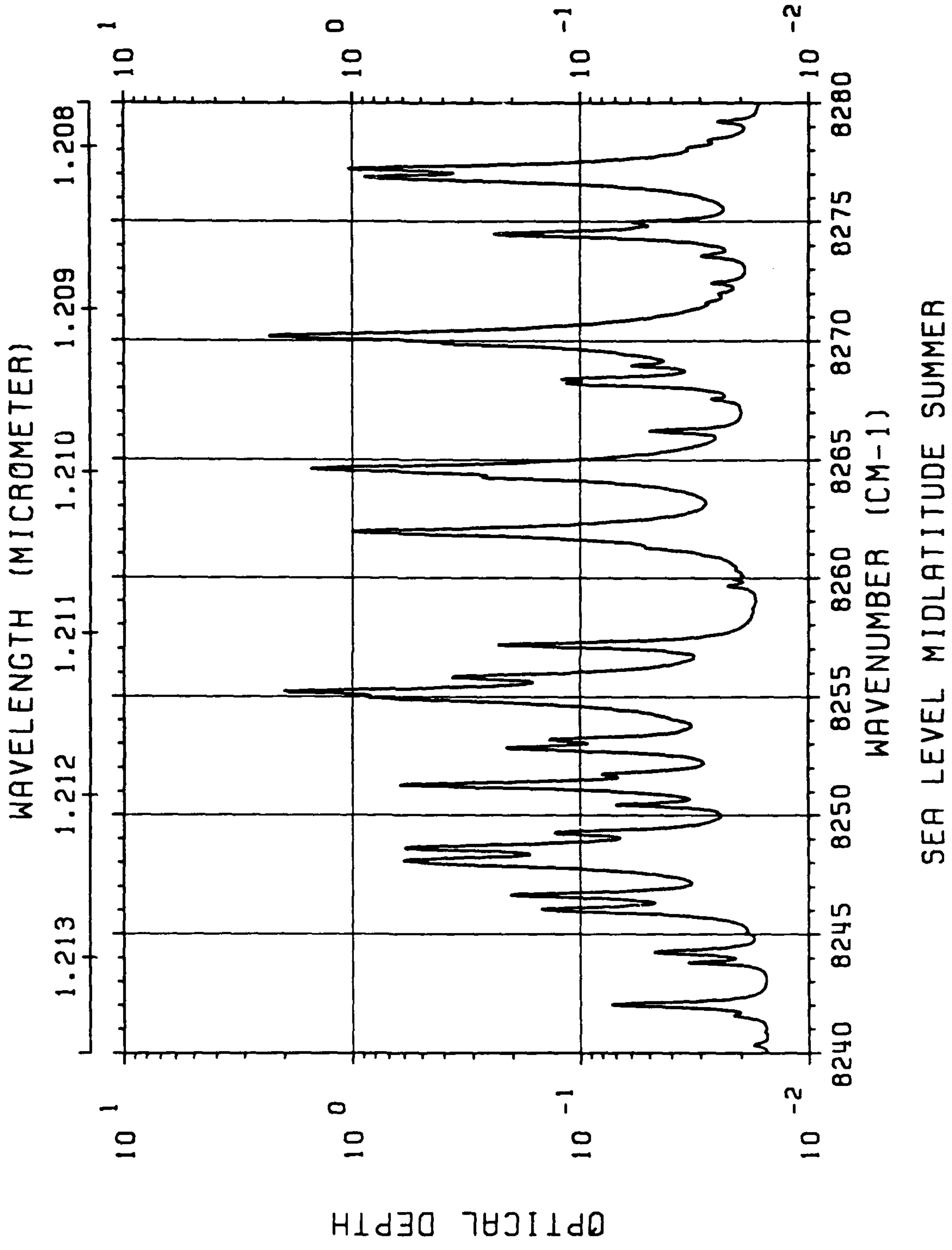
SEA LEVEL MIDLATITUDE SUMMER

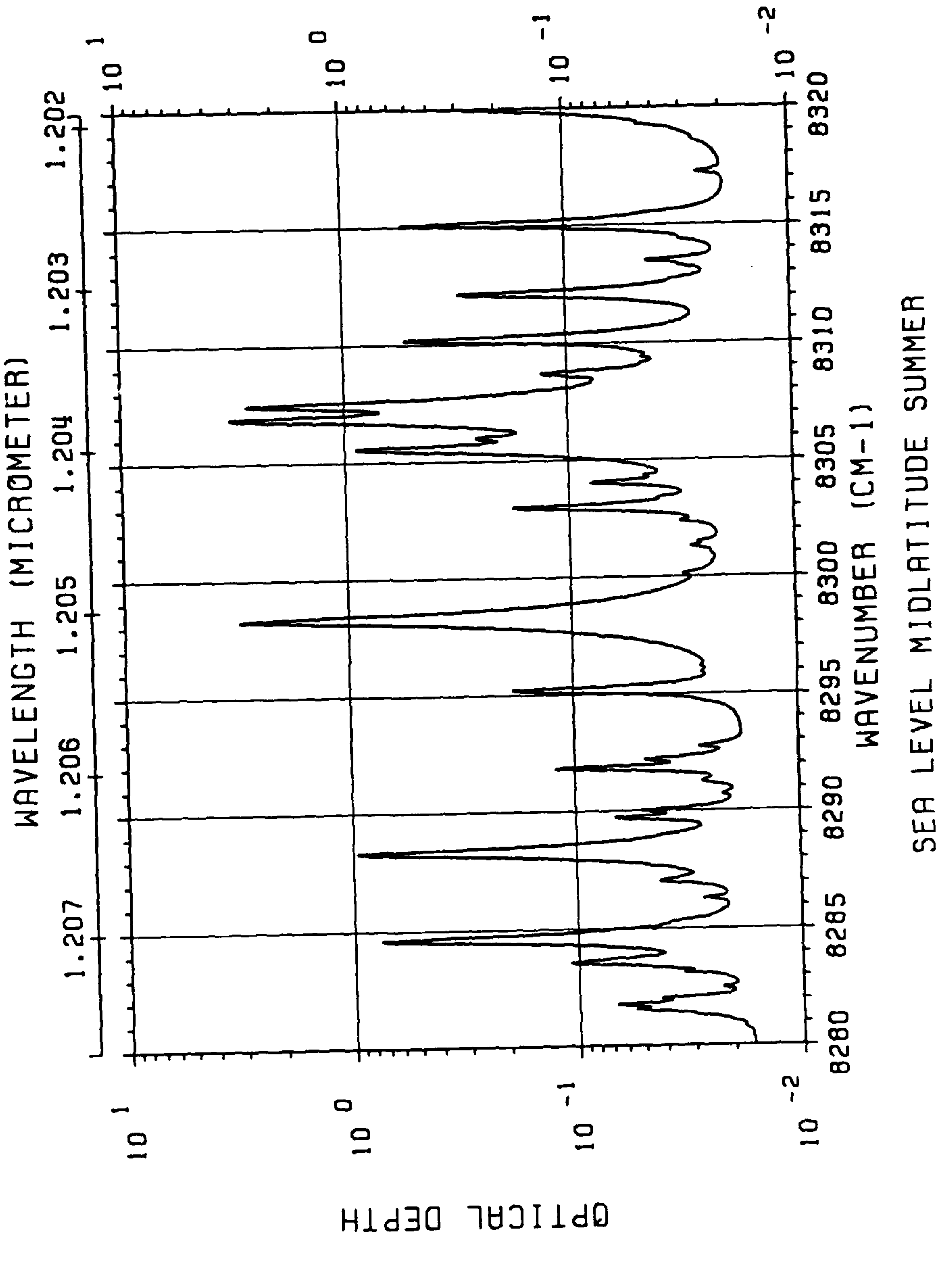


SEA LEVEL MIDLATITUDE SUMMER

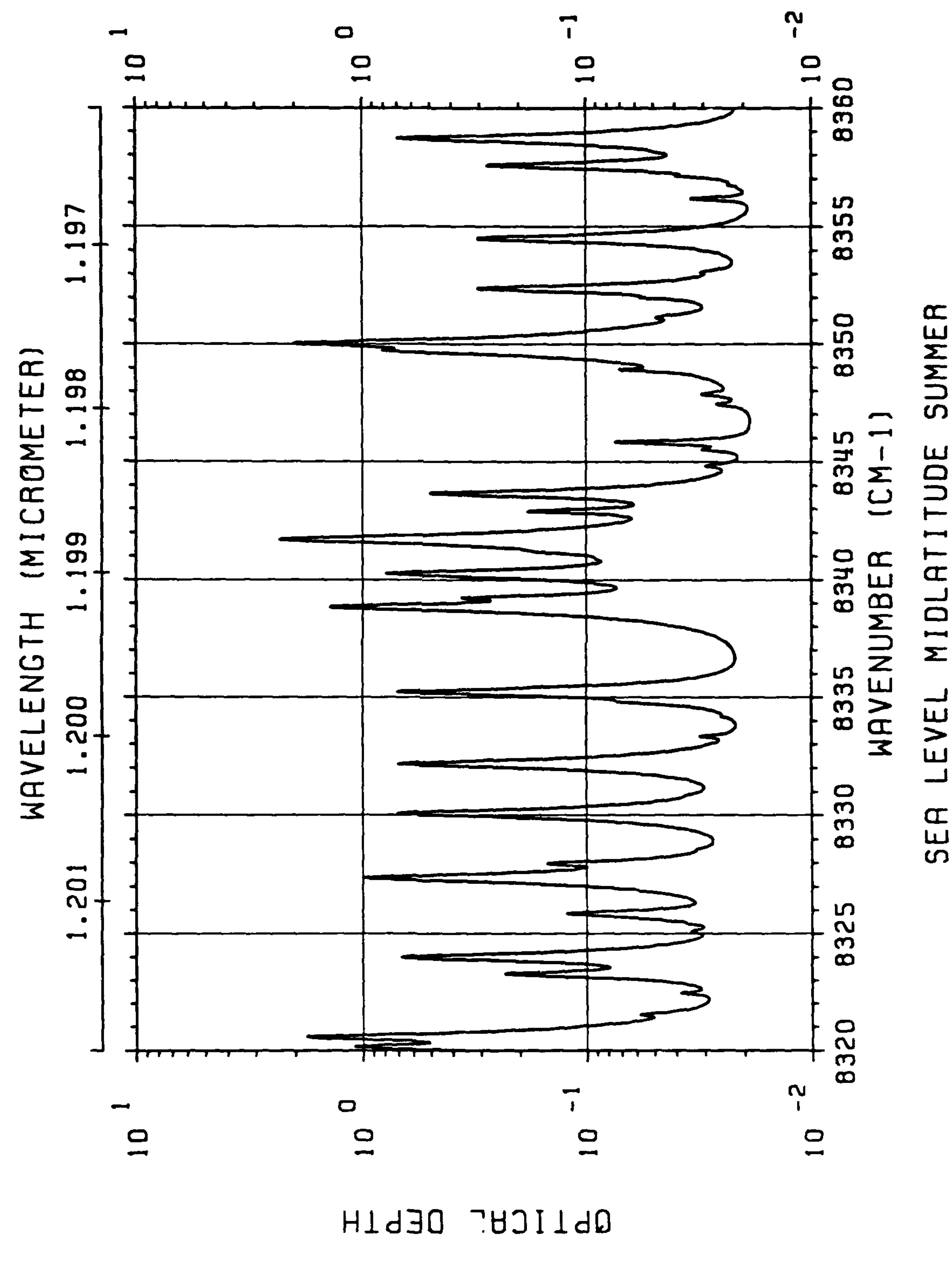


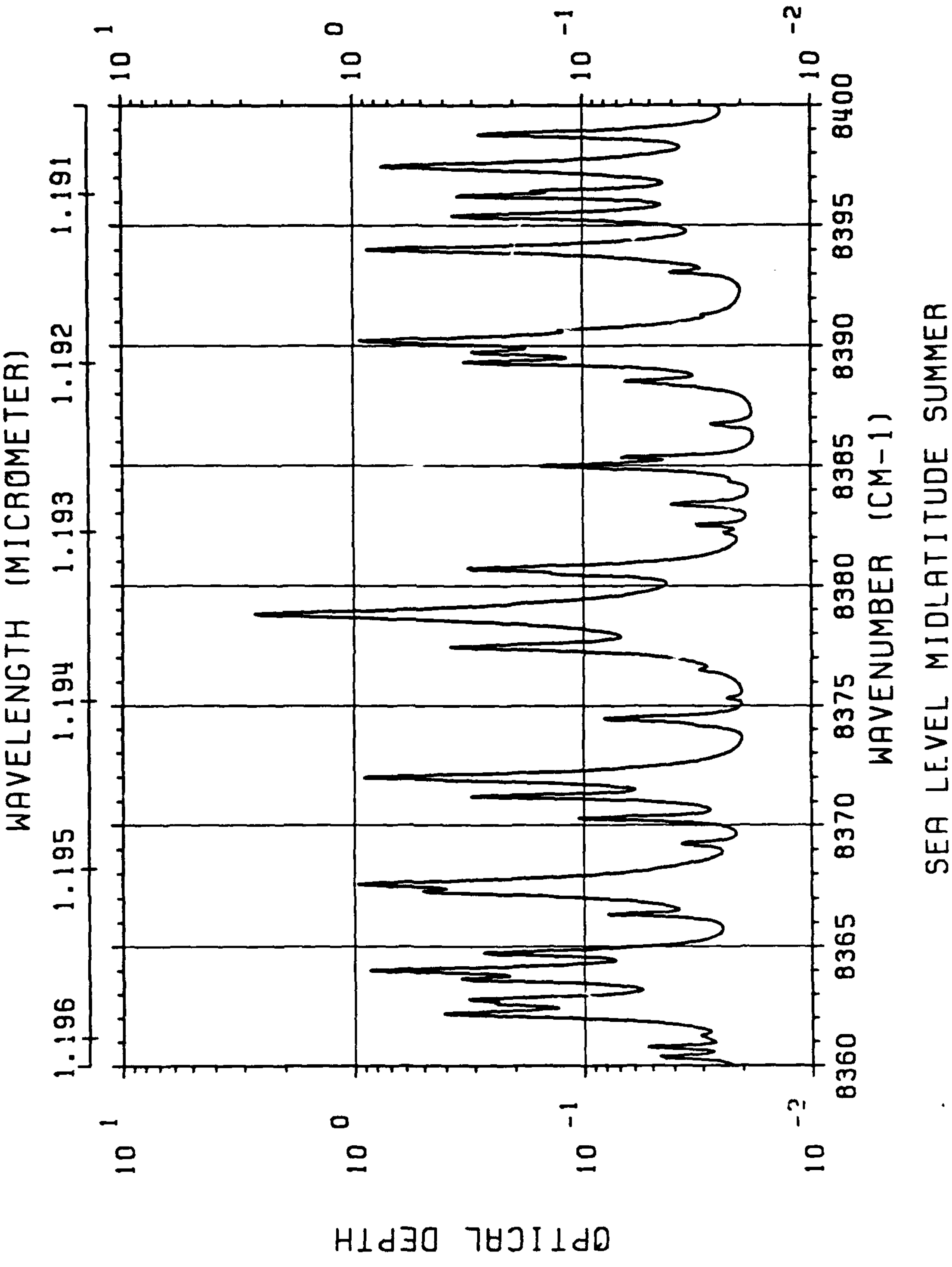
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.208
1.209
1.210
1.211
1.212
1.213
8240
8245
8250
8255
8260
8265
8270
8275
8280
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
10^{1}
10^{0}
10^{-1}
10^{-2}
OPTICAL DEPTH

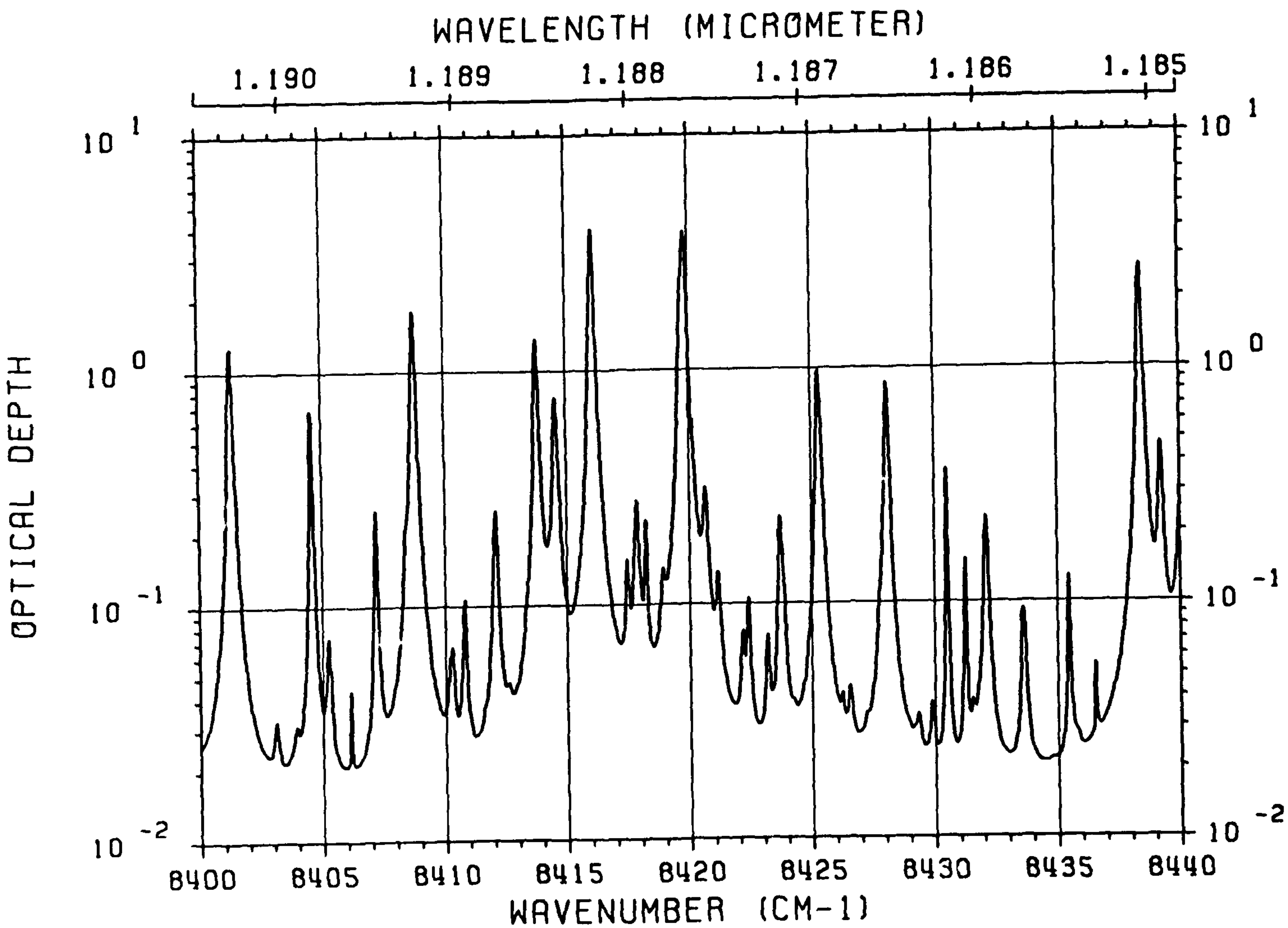


WAVELENGTH (MICROMETER)
1.202
1.203
1.204
1.205
1.206
1.207
10^{1}
10^{0}
10^{-1}
10^{-2}
OPTICAL DEPTH
8280
8285
8290
8295
8300
8305
8310
8315
8320
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

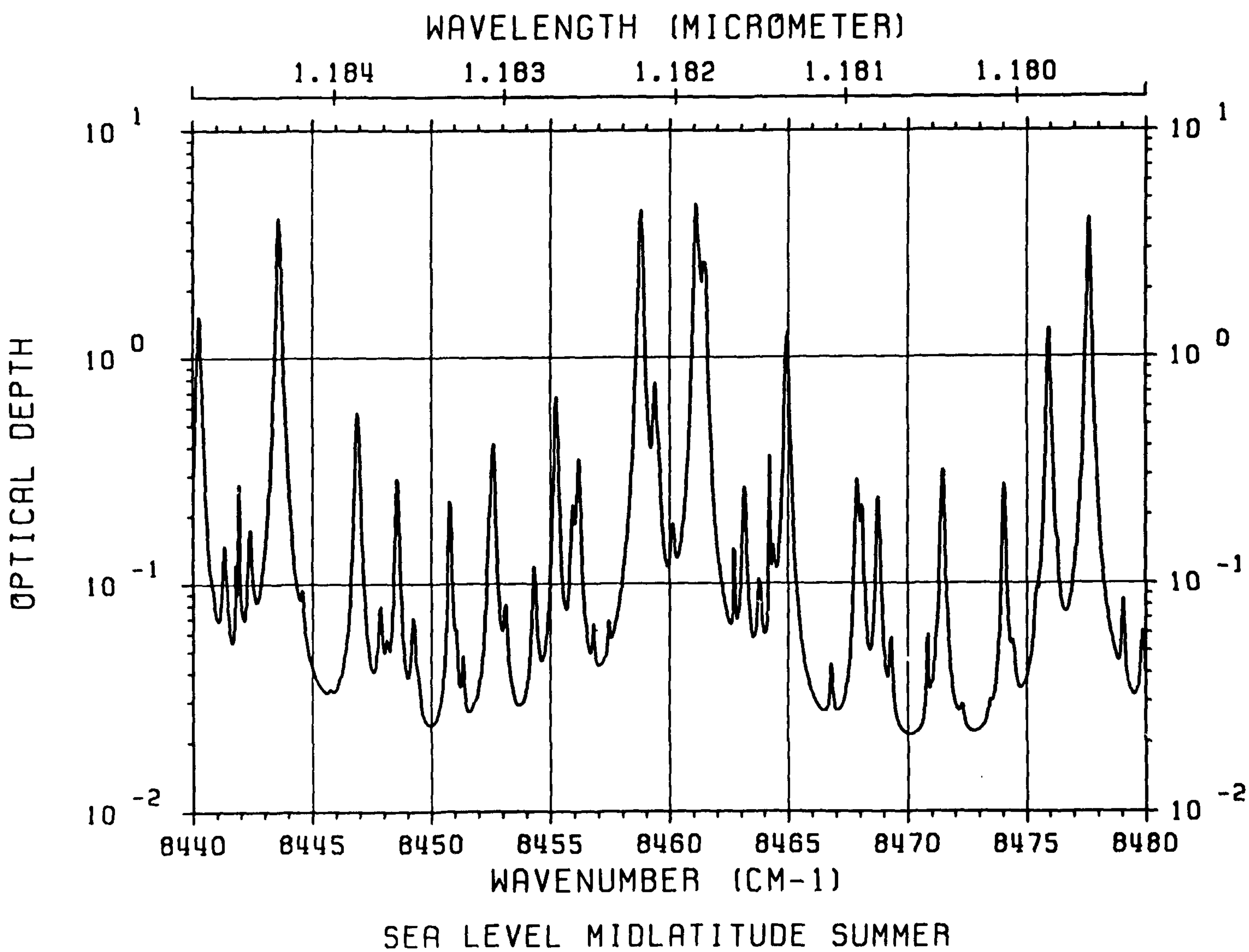

WAVELENGTH (MICROMETER)
1.197
1.198
1.199
1.200
1.201
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}
8320
8325
8330
8335
8340
8345
8350
8355
8360
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

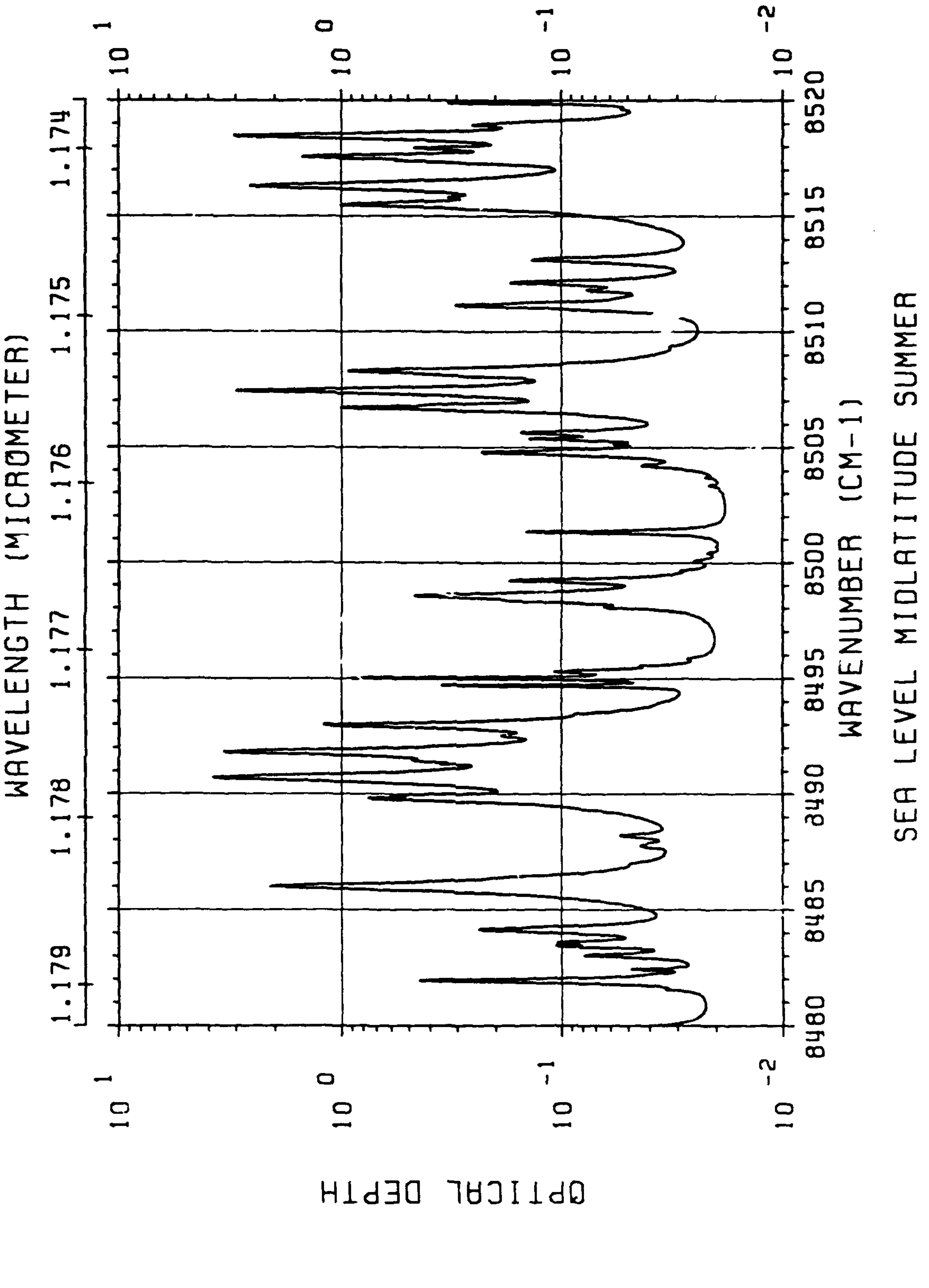


WAVELENGTH (MICROMETER)
1.191
1.192
1.193
1.194
1.195
1.196
WAVENUMBER (CM-1)
8360
8365
8370
8375
8380
8385
8390
8395
8400
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}

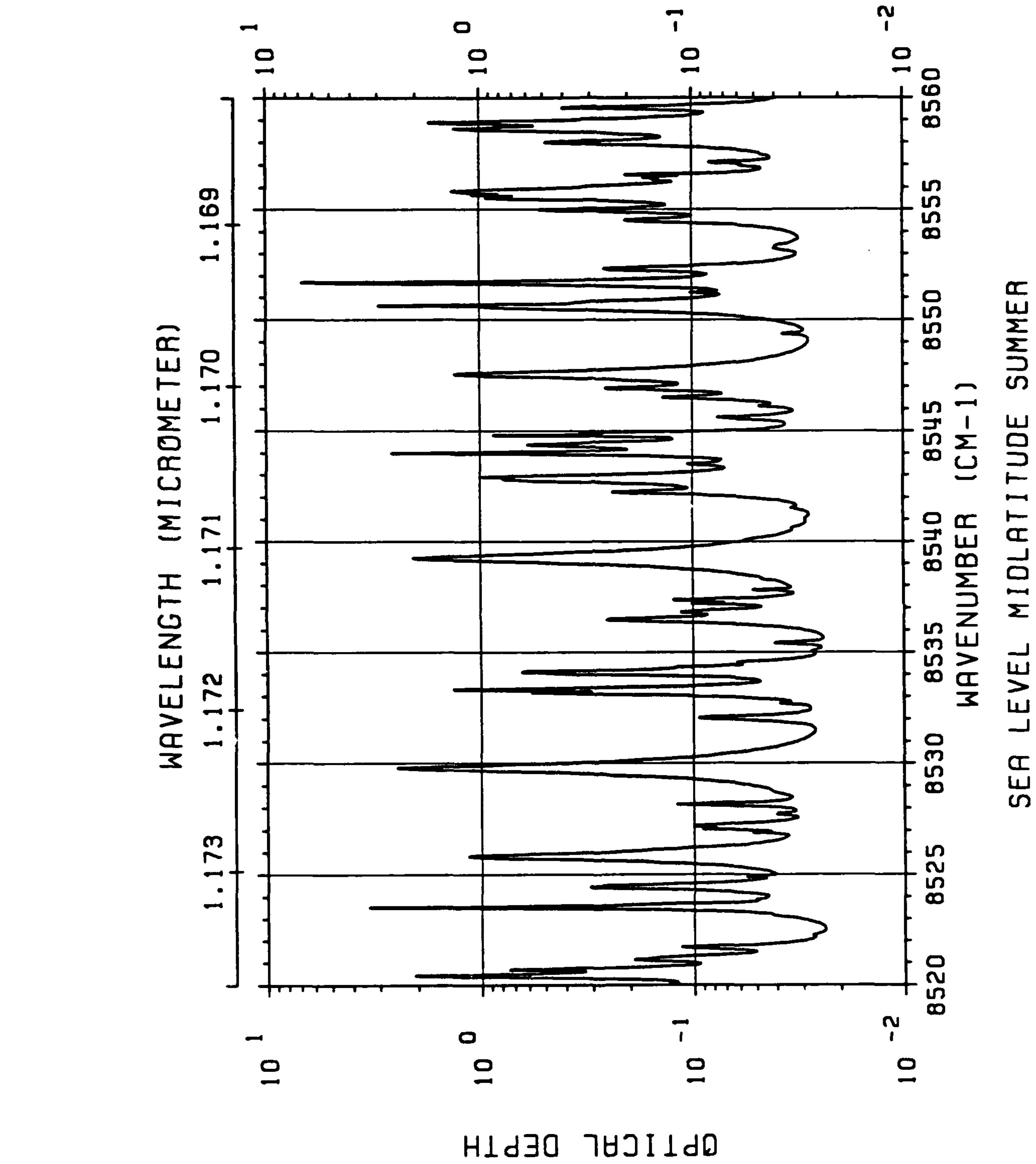


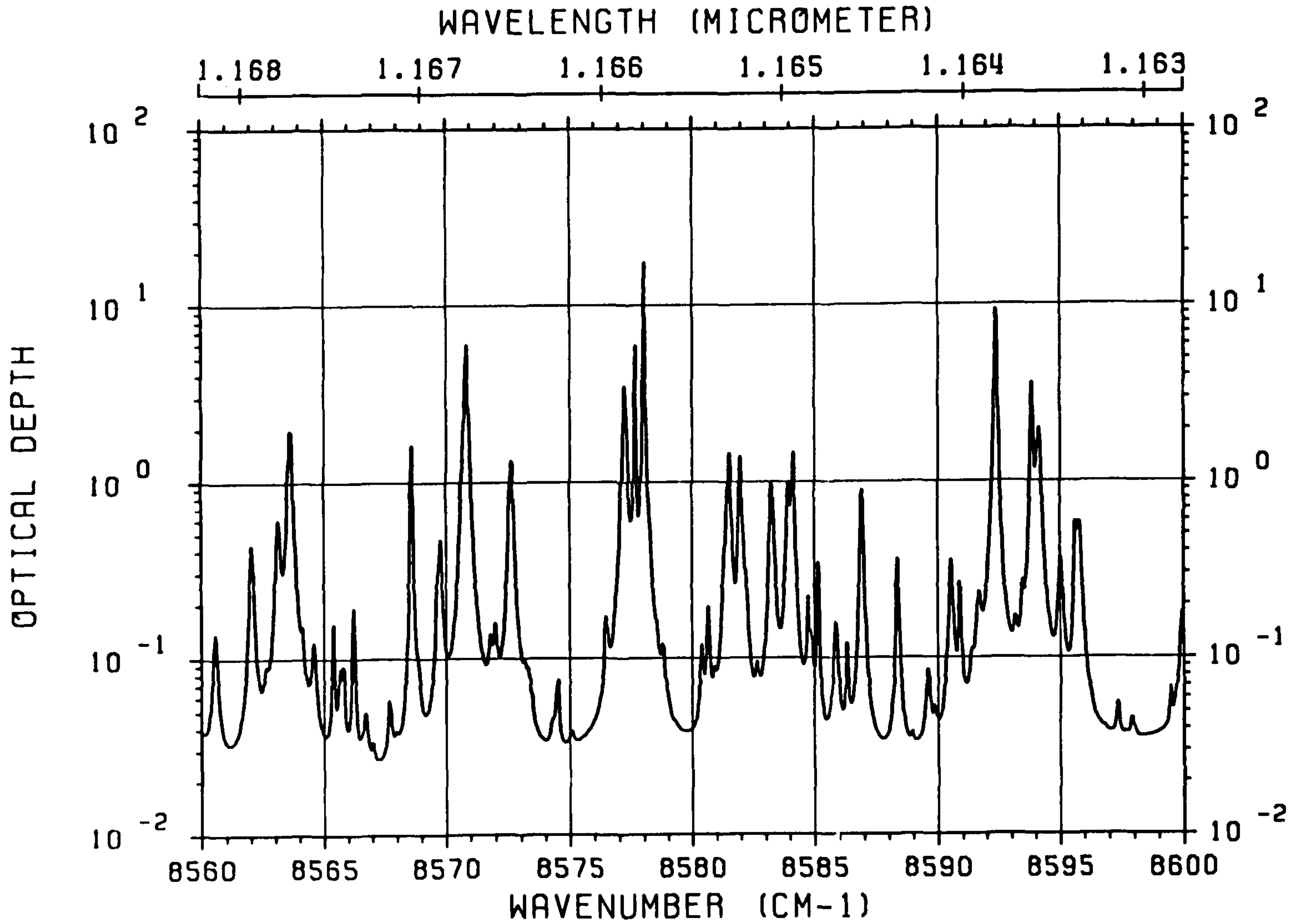
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICRØMETER)
1.184
1.183
1.182
1.181
1.180
10^{1}
10^{0}
10^{-1}
10^{-2}
ØPTICAL DEPTH
8440
8445
8450
8455
8460
8465
8470
8475
8480
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

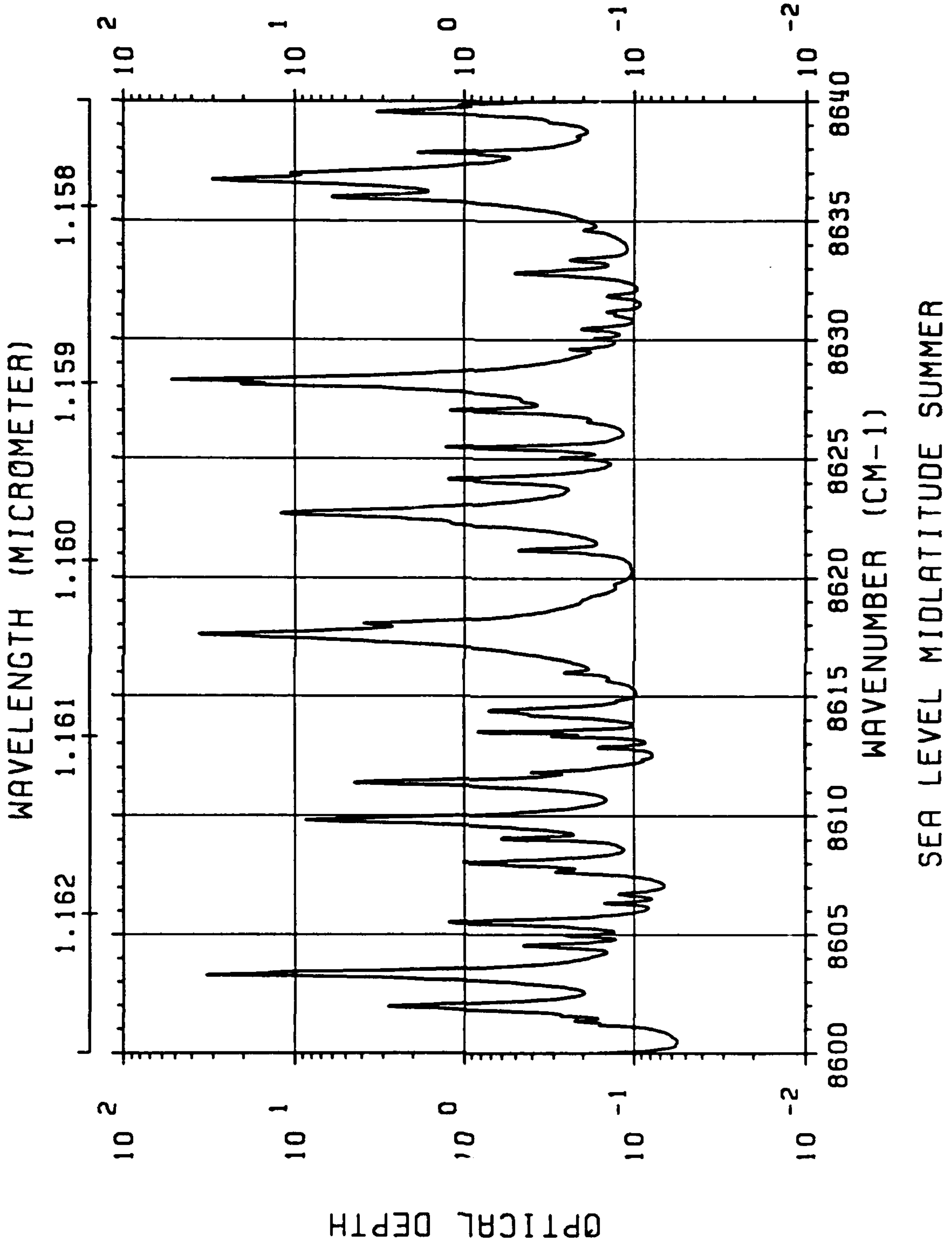


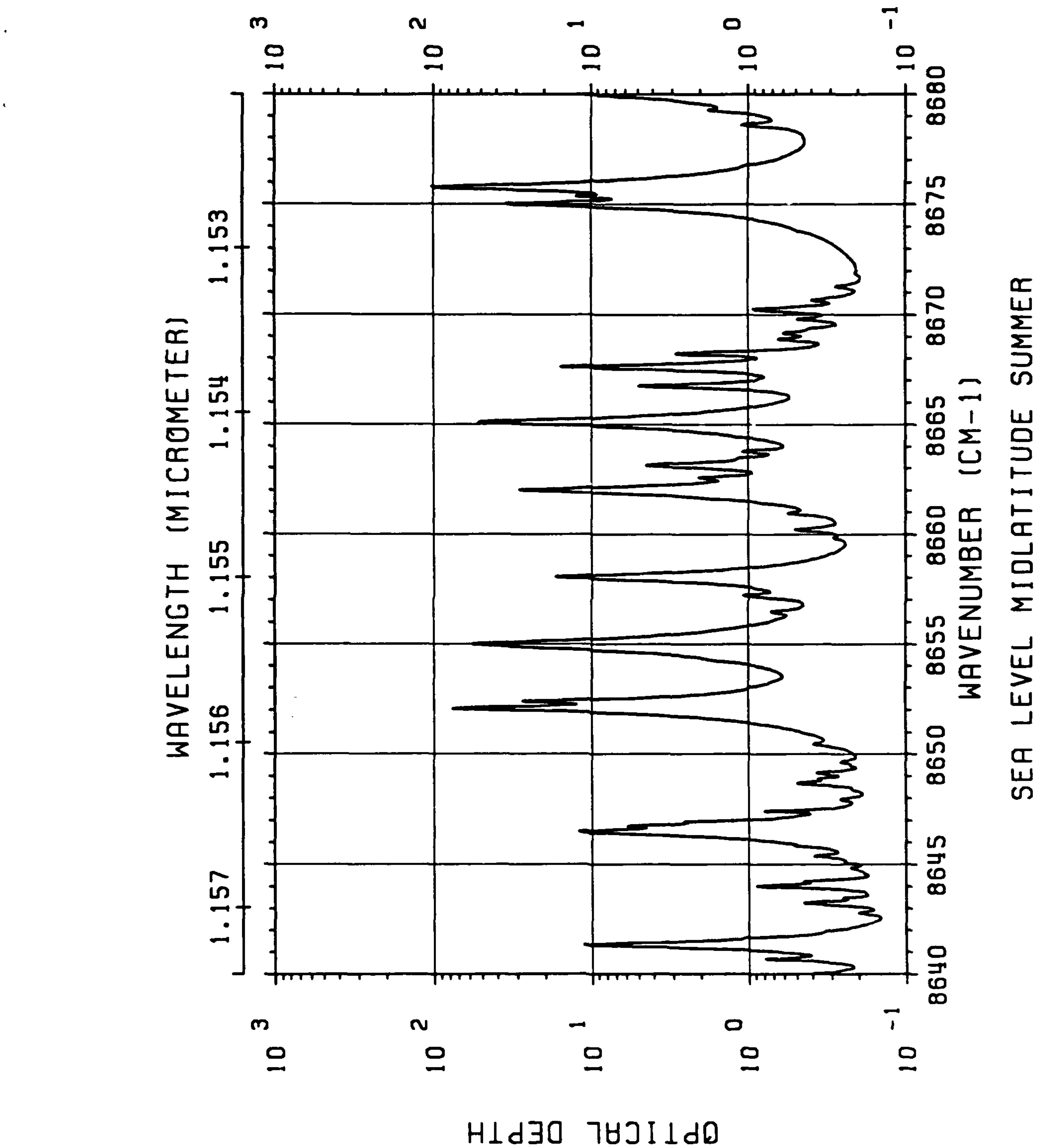
WAVELENGTH (MICROMETER)
1.179
1.178
1.177
1.176
1.175
1.174
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}
8480
8485
8490
8495
8500
8505
8510
8515
8520
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

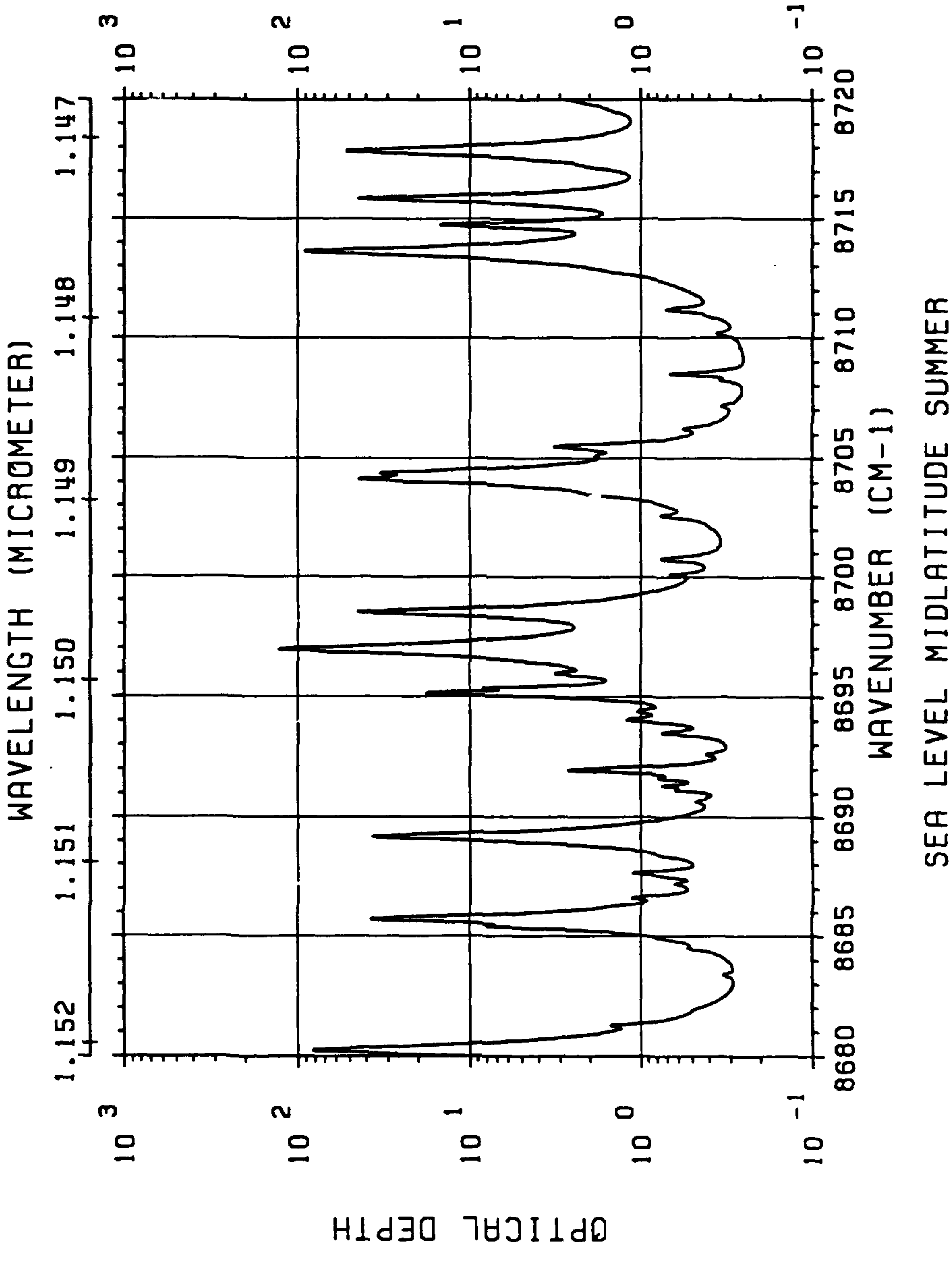

WAVELENGTH (MICROMETER)
1.169
1.170
1.171
1.172
1.173
OPTICAL DEPTH
10^1
10^0
10^-1
10^-2
8520
8525
8530
8535
8540
8545
8550
8555
8560
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

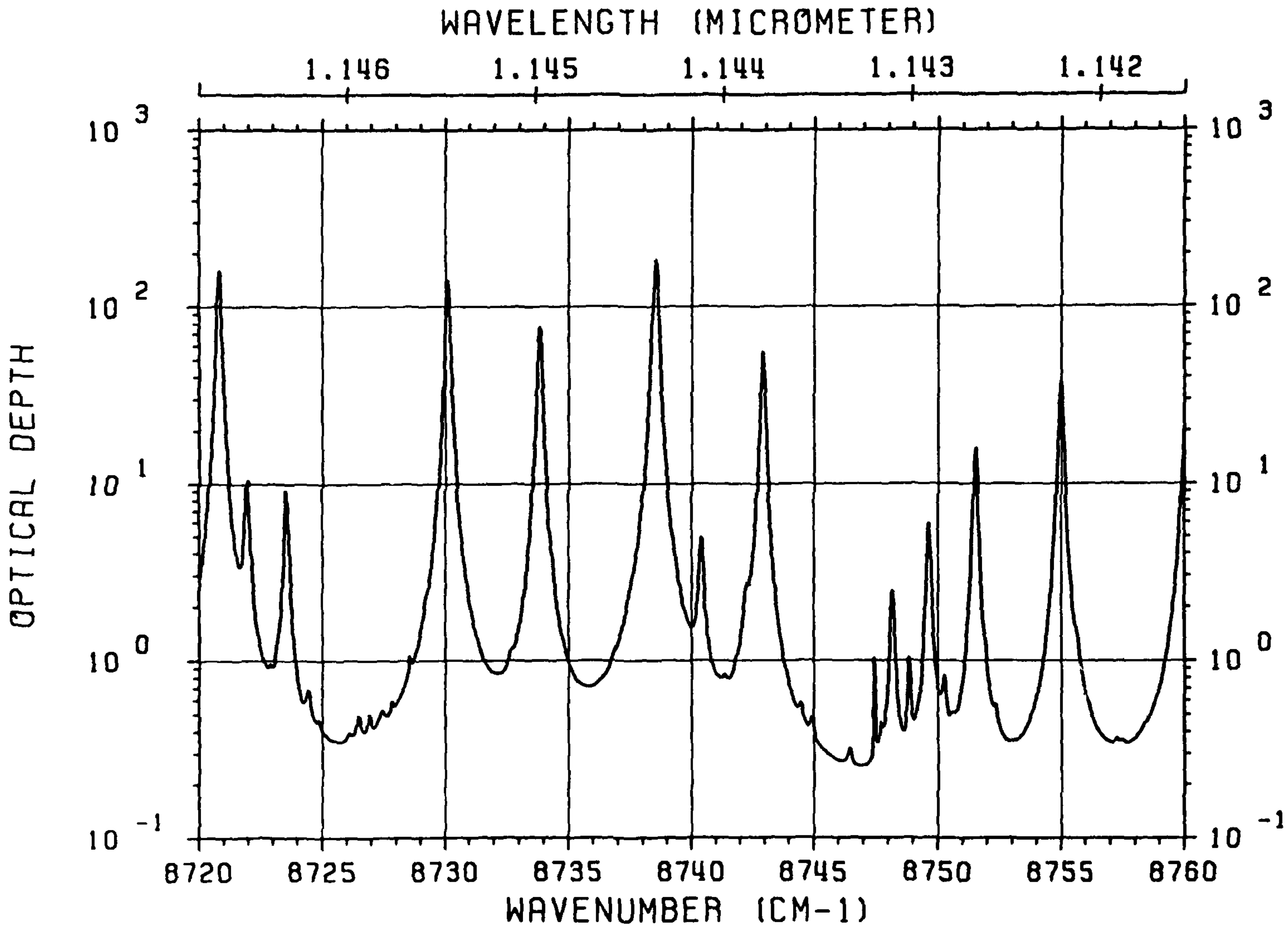


SEA LEVEL MIDLATITUDE SUMMER

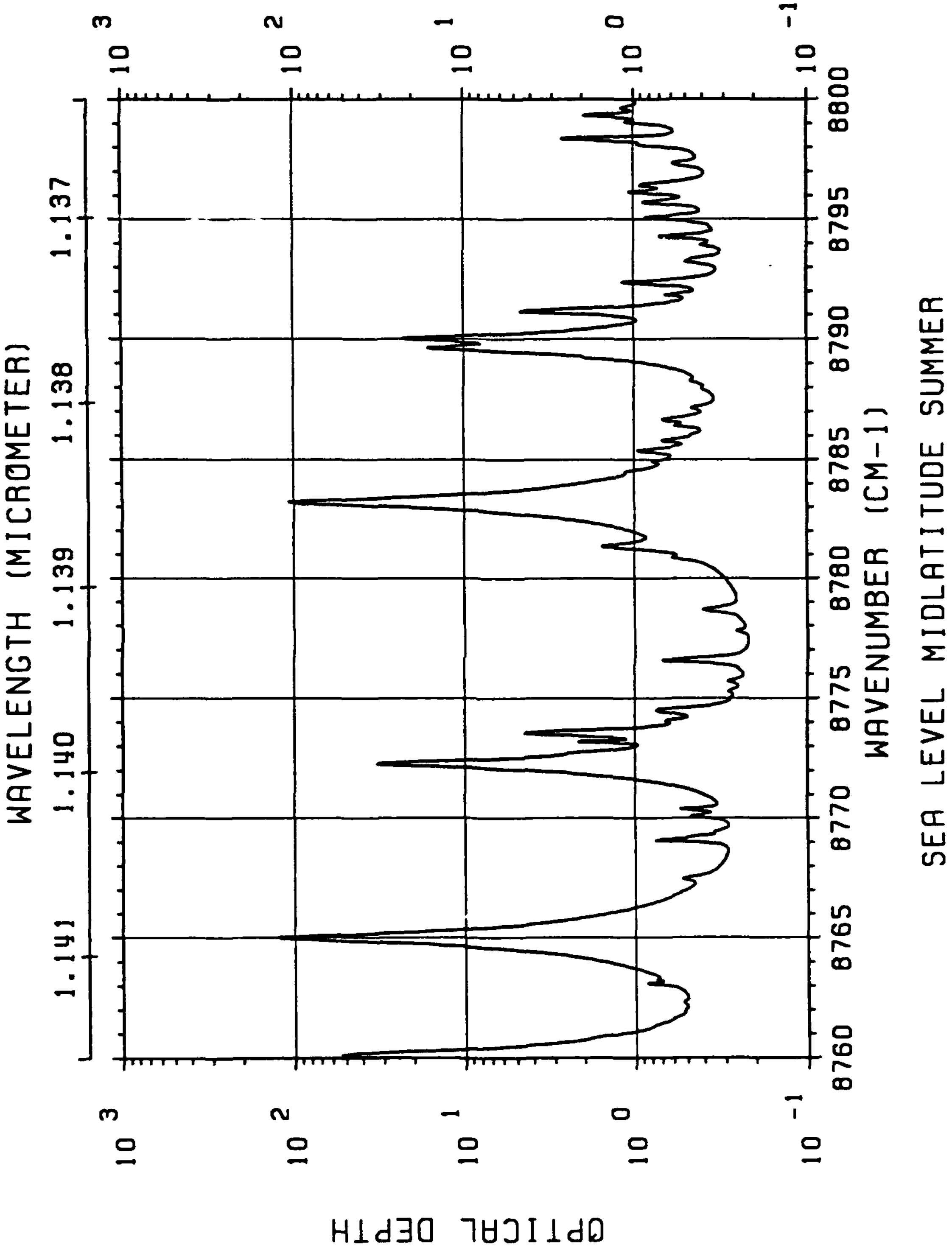

WAVELENGTH (MICROMETER)
1.158
1.159
1.160
1.161
1.162
OPTICAL DEPTH
10 2
10 1
10 0
10 -1
10 -2
8600
8605
8610
8615
8620
8625
8630
8635
8640
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.153
1.154
1.155
1.156
1.157
OPTICAL DEPTH
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
8640
8645
8650
8655
8660
8665
8670
8675
8680
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

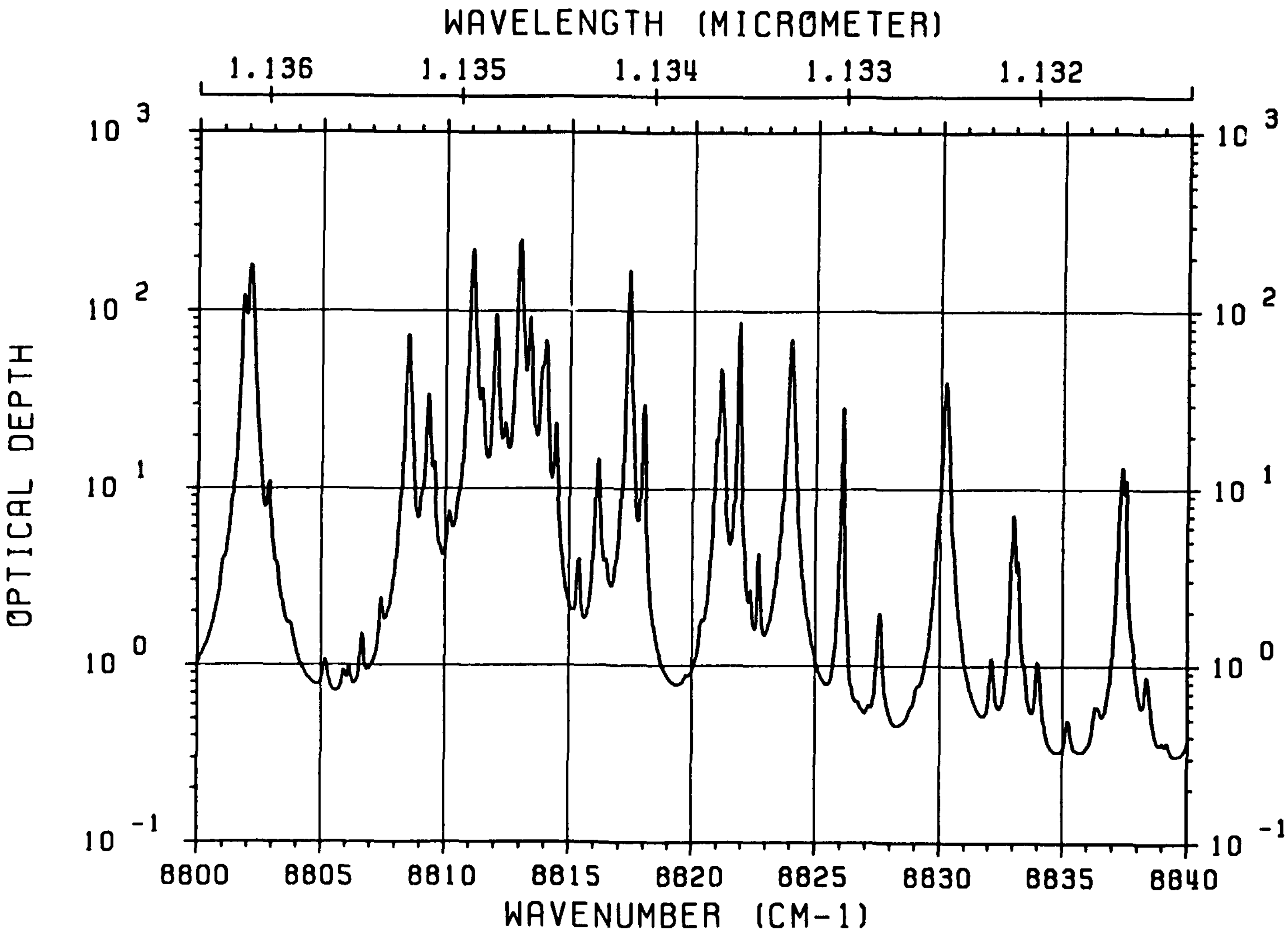

WAVELENGTH (MICROMETER)
1.152
1.151
1.150
1.149
1.148
1.147
10^3
10^2
10^1
10^0
10^-1
OPTICAL DEPTH
8680
8685
8690
8695
8700
8705
8710
8715
8720
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



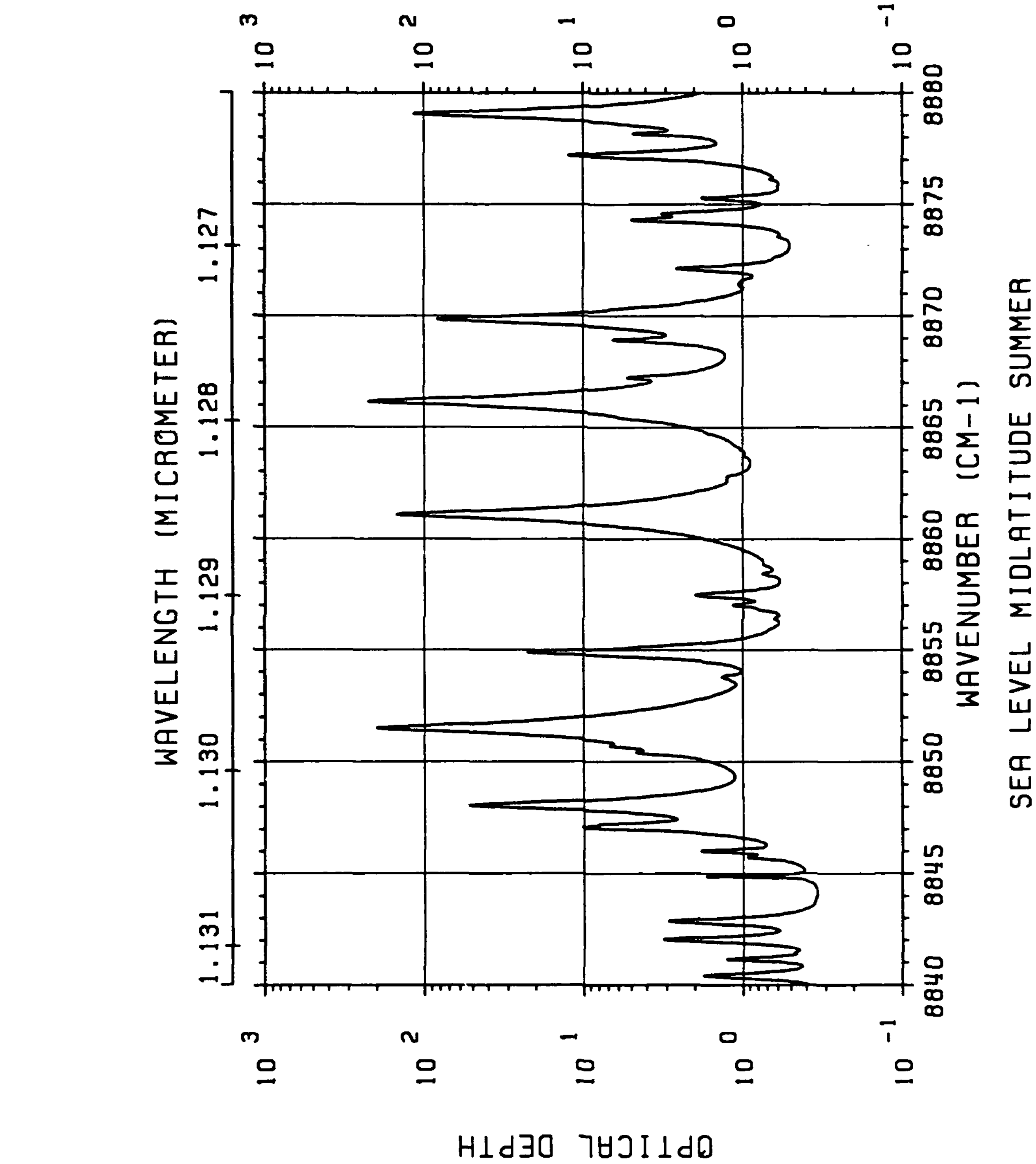
SEA LEVEL MIDLATITUDE SUMMER



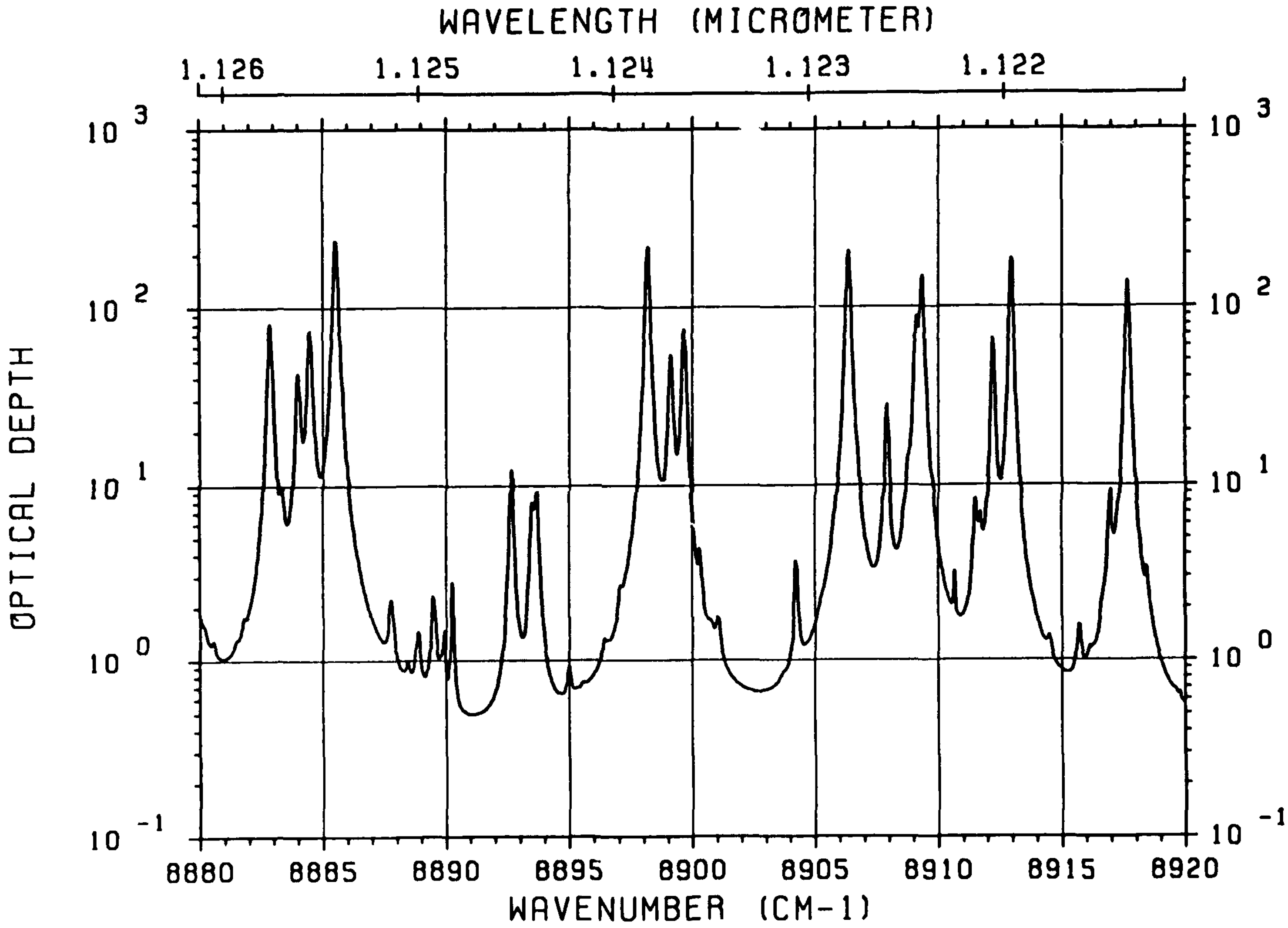
WAVELENGTH (MICROMETER)
1.137
1.138
1.139
1.140
1.141
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
OPTICAL DEPTH
8760
8765
8770
8775
8780
8785
8790
8795
8800
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



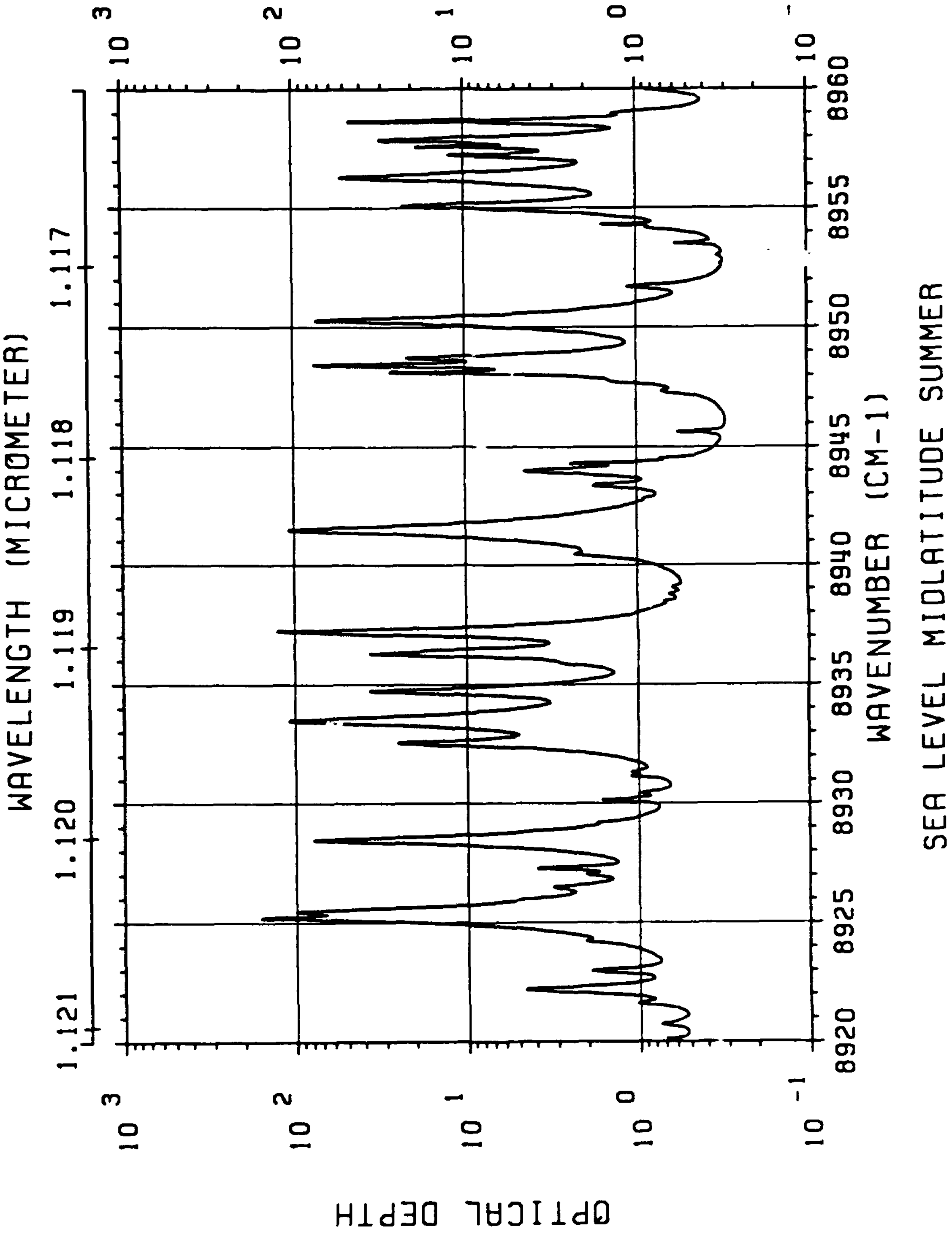
SEA LEVEL MIDLATITUDE SUMMER

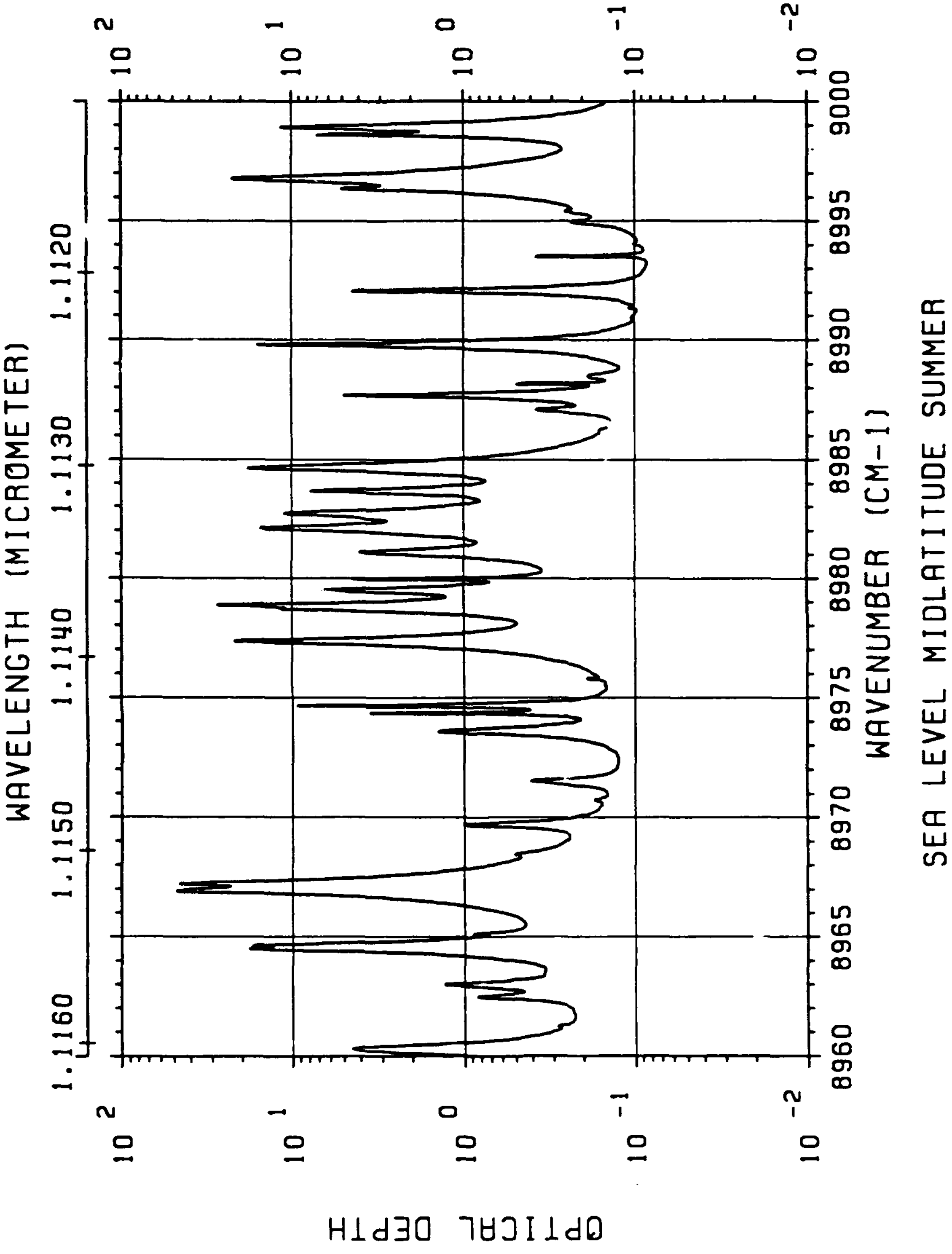


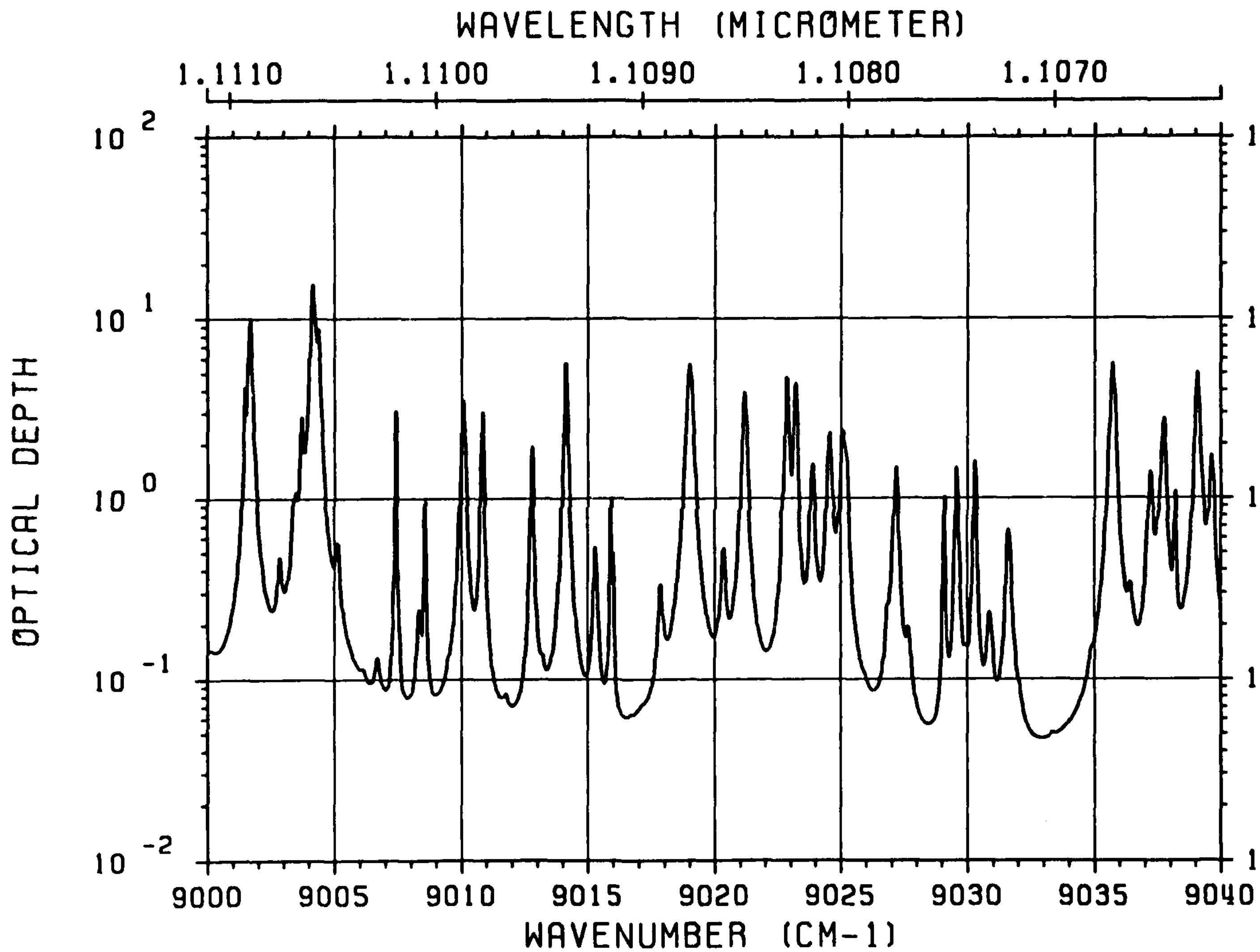
WAVELENGTH (MICROMETER)
1.131
1.130
1.129
1.128
1.127
OPTICAL DEPTH
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
8840
8845
8850
8855
8860
8865
8870
8875
8880
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



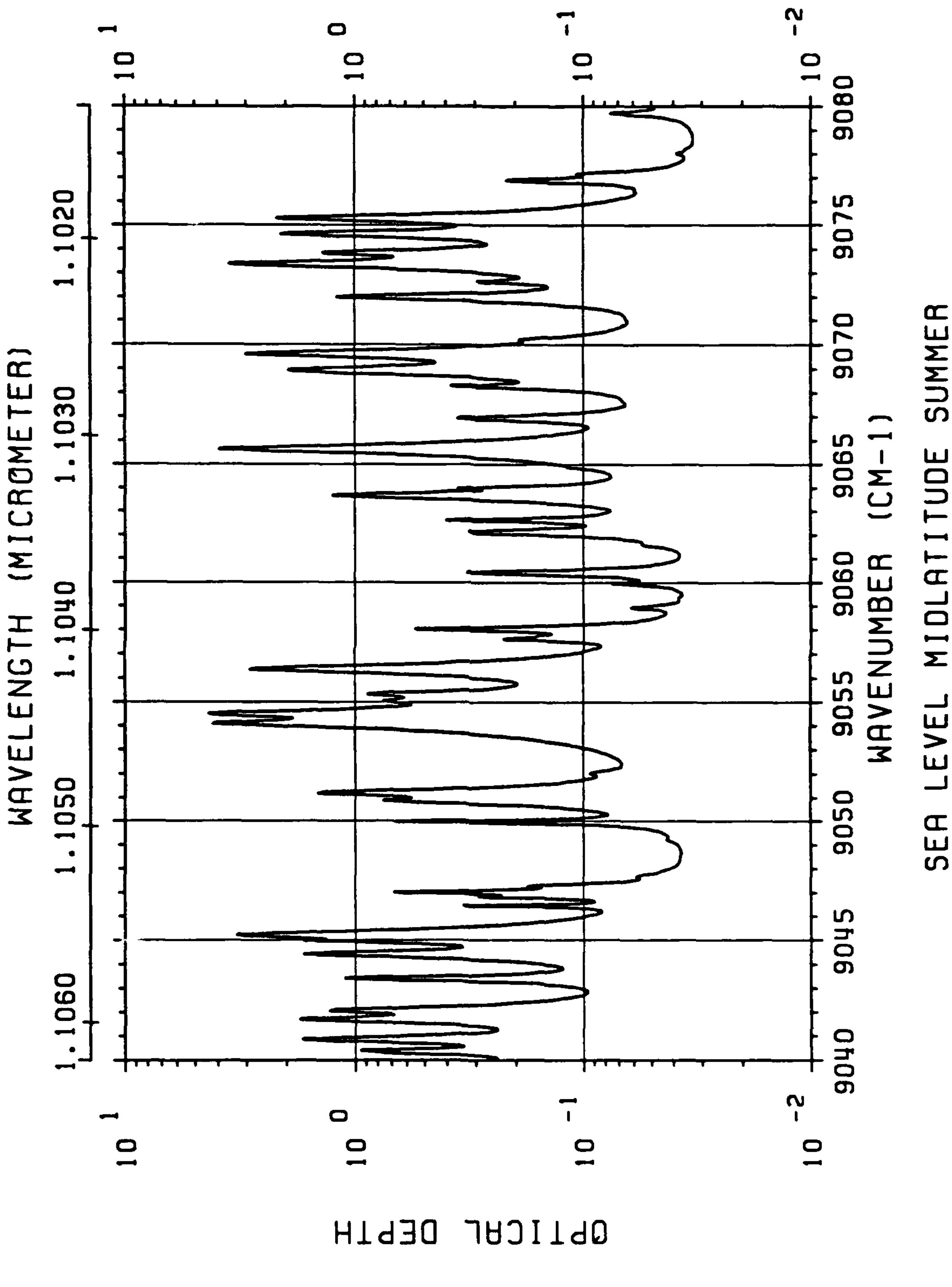
SEA LEVEL MIDLATITUDE SUMMER

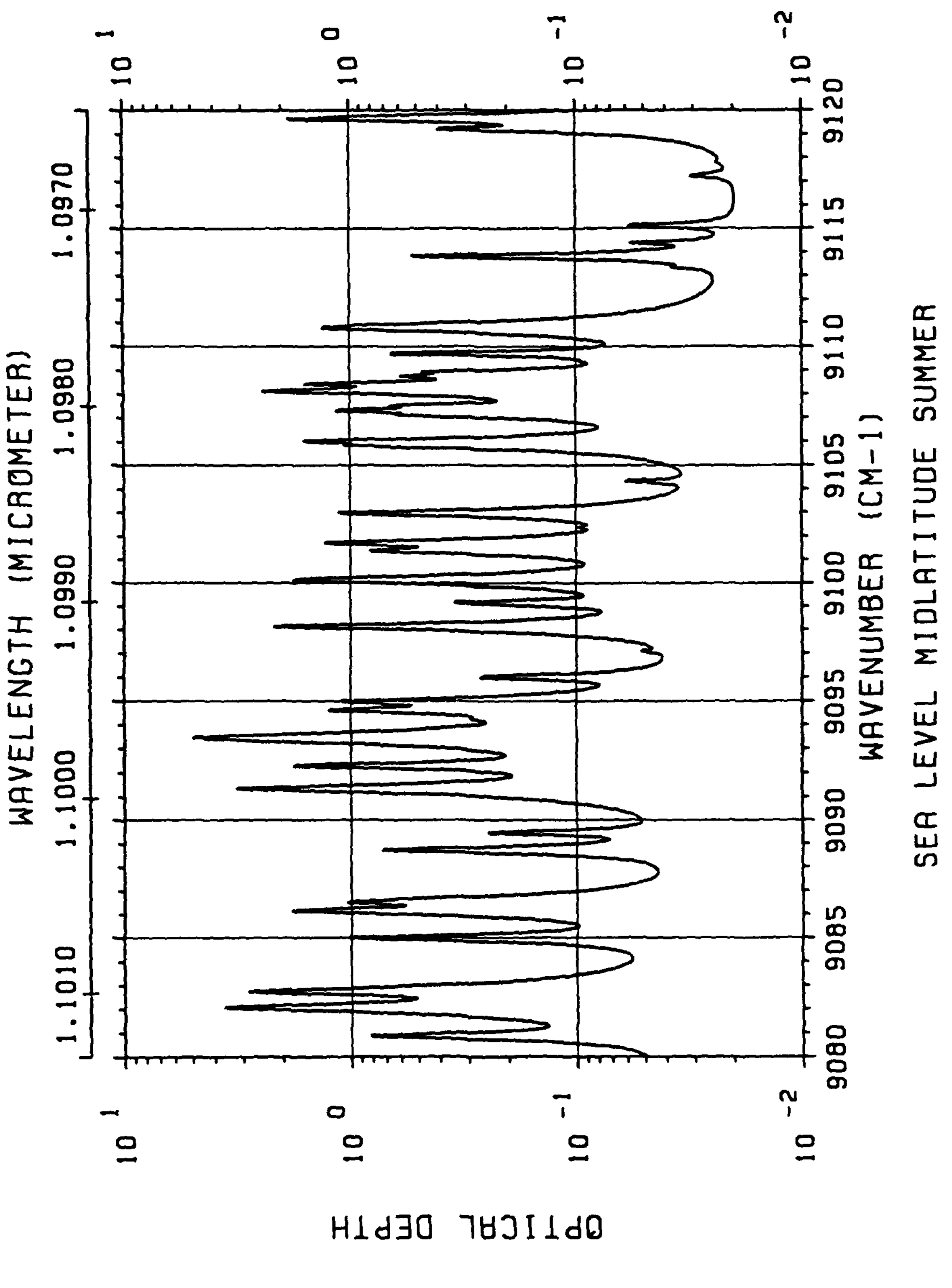

WAVELENGTH (MICROMETER)
1.121
1.120
1.119
1.118
1.117
OPTICAL DEPTH
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
8920
8925
8930
8935
8940
8945
8950
8955
8960
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

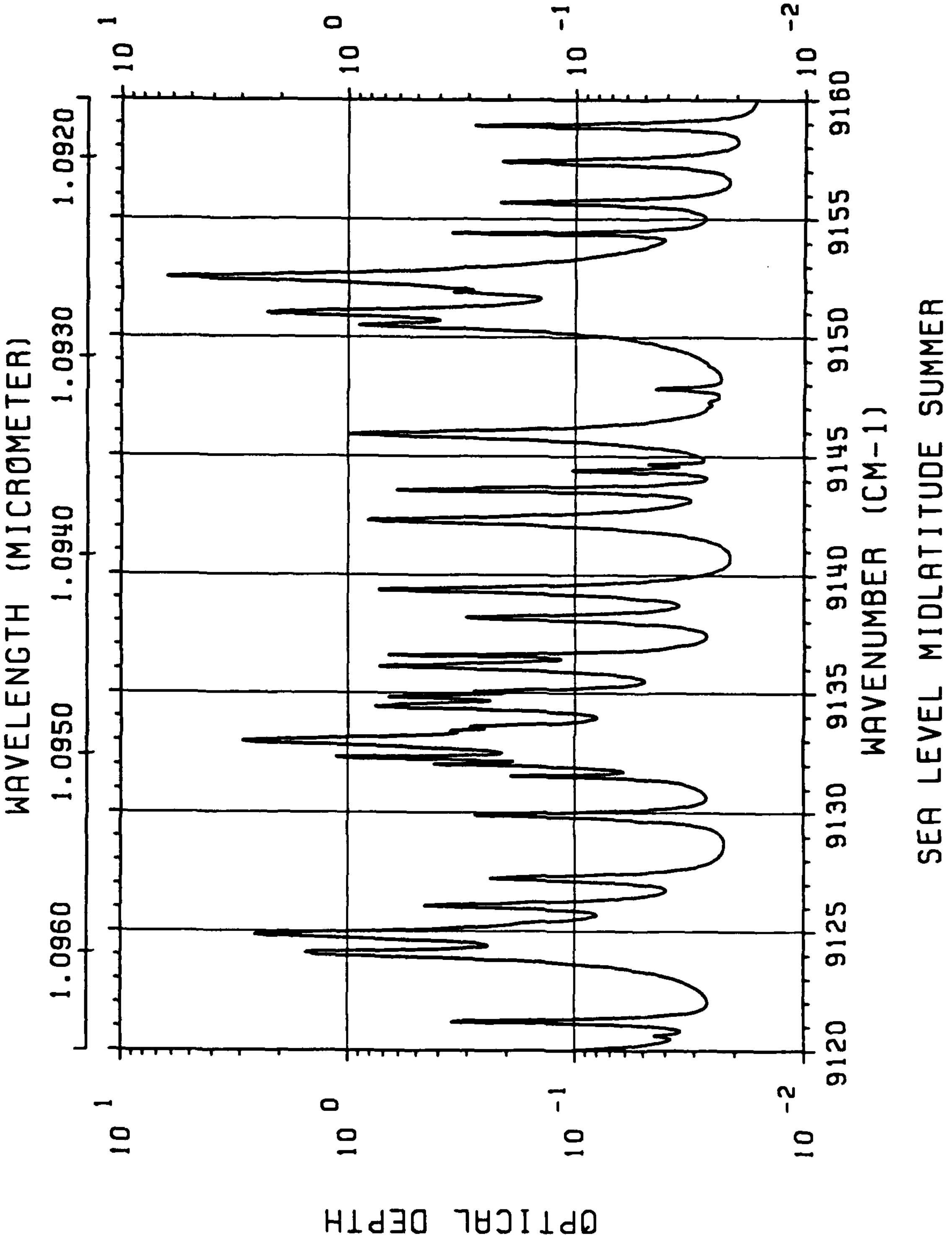

WAVELENGTH (MICROMETER)
1.1160
1.1150
1.1140
1.1130
1.1120
OPTICAL DEPTH
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
8960
8965
8970
8975
8980
8985
8990
8995
9000
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER



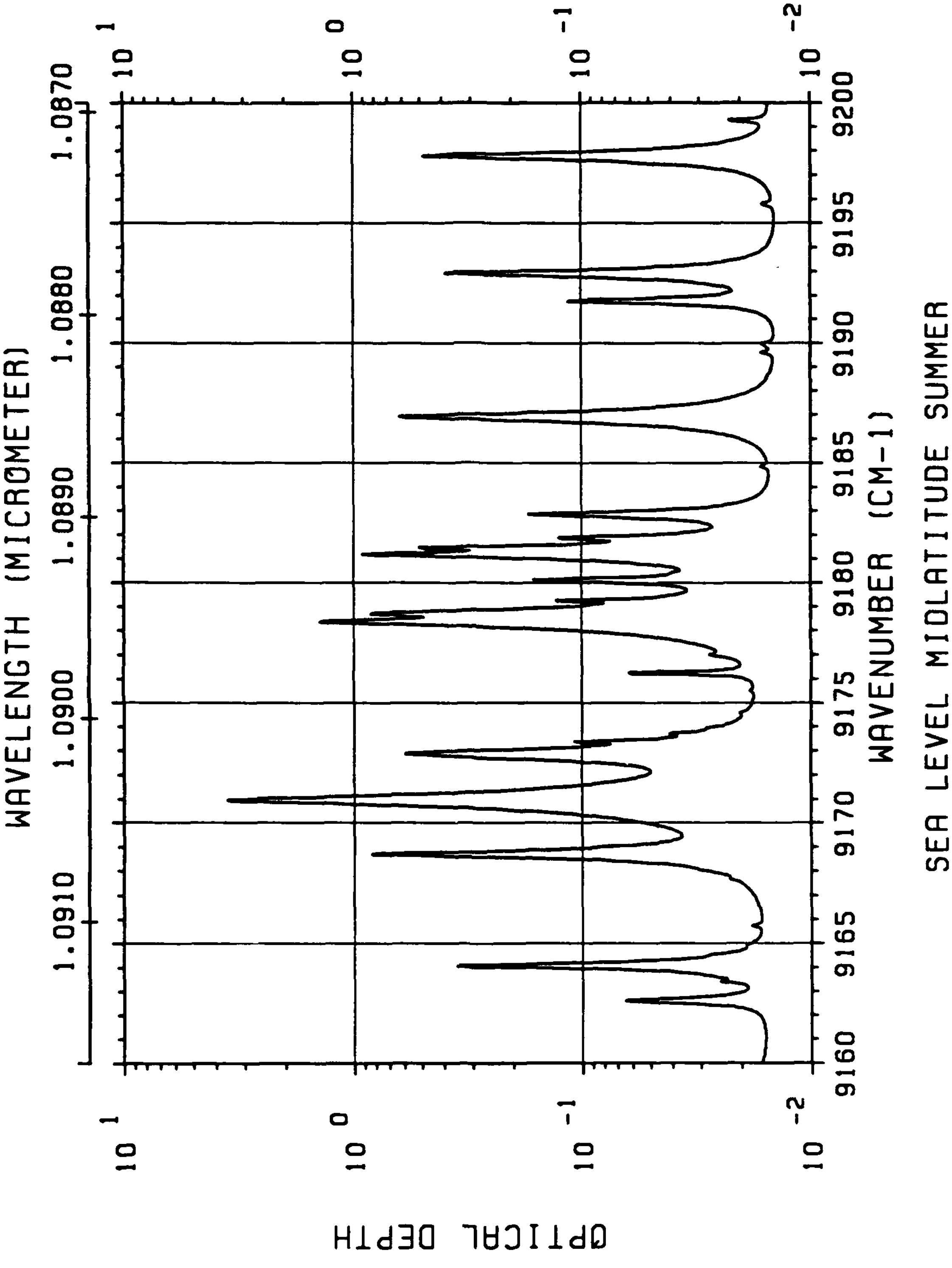
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.1020
1.1030
1.1040
1.1050
1.1060
10^{1}
10^{0}
10^{-1}
10^{-2}
9040
9045
9050
9055
9060
9065
9070
9075
9080
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH

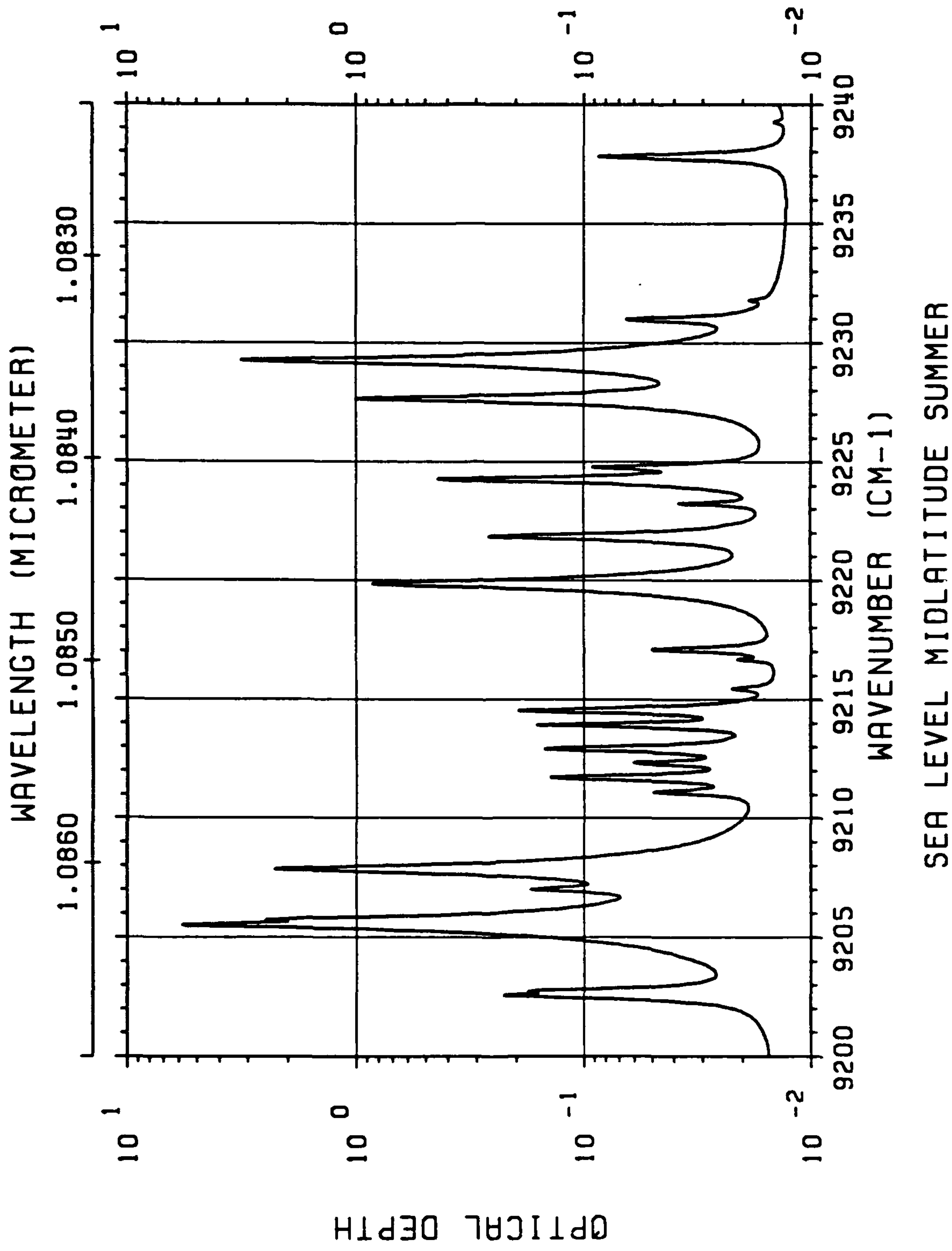

WAVELENGTH (MICROMETER)
1.1010
1.1000
1.0990
1.0980
1.0970
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}
9080
9085
9090
9095
9100
9105
9110
9115
9120
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

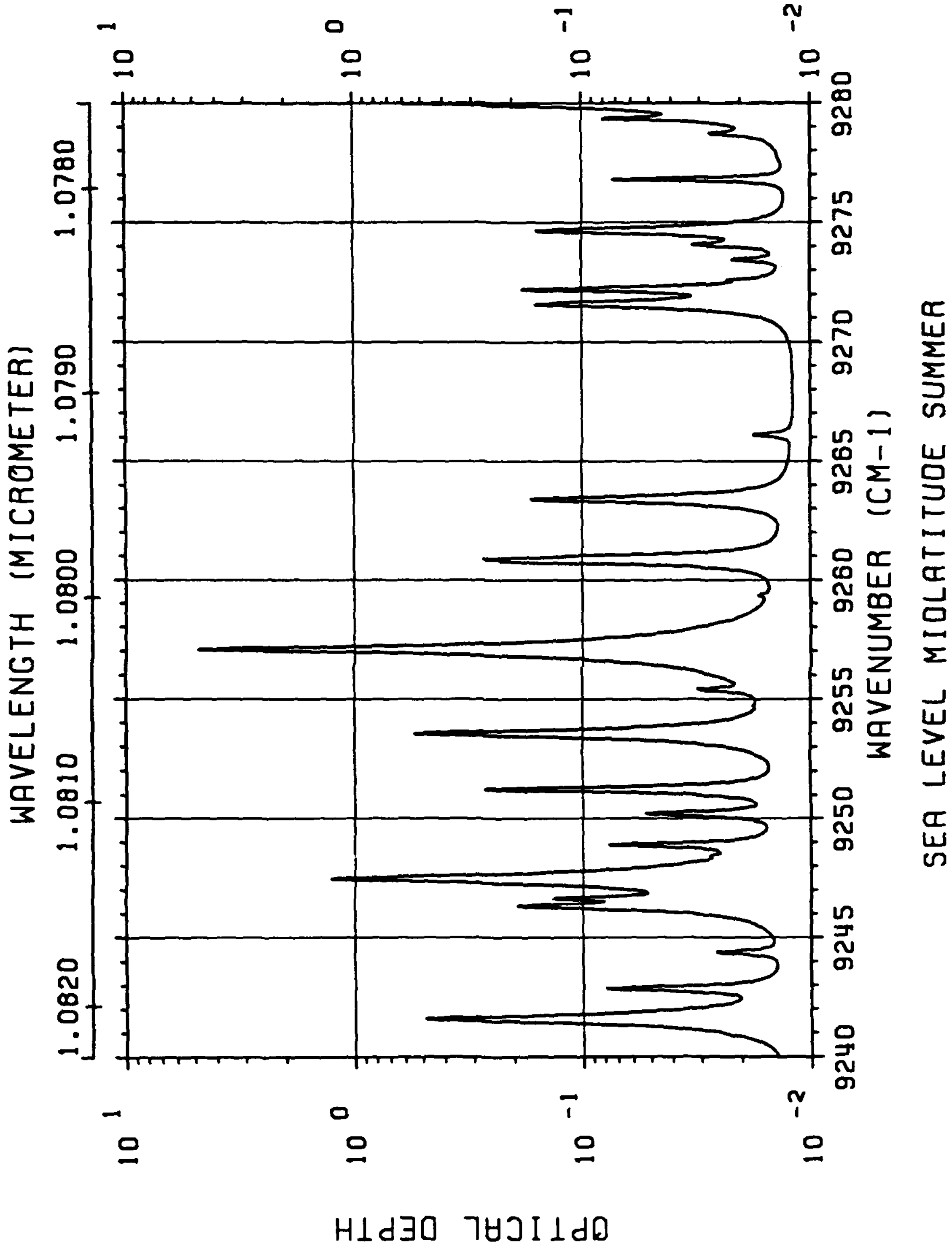


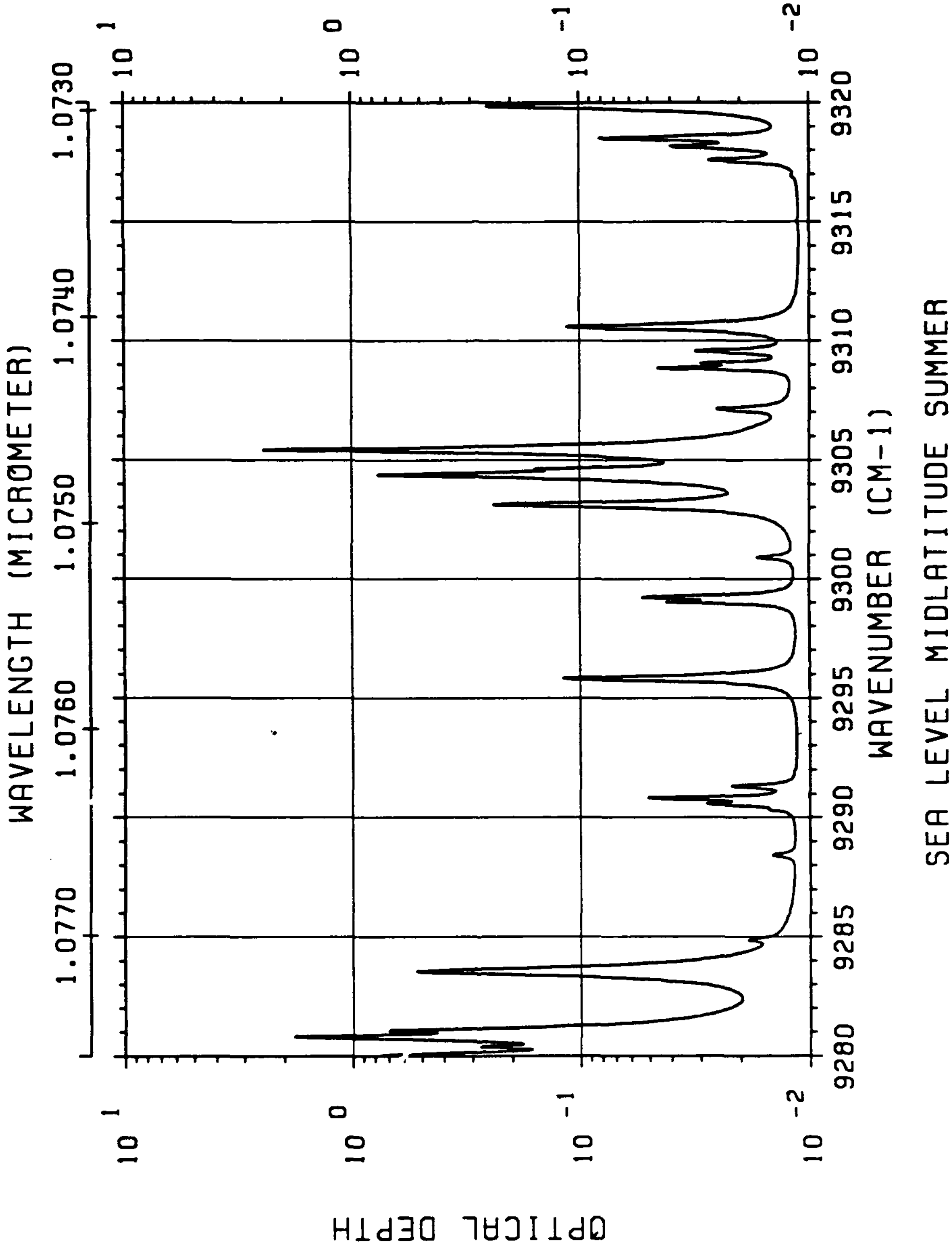
WAVELENGTH (MICRØMETER)
1.0920
1.0930
1.0940
1.0950
1.0960
WAVENUMBER (CM-1)
9120
9125
9130
9135
9140
9145
9150
9155
9160
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}

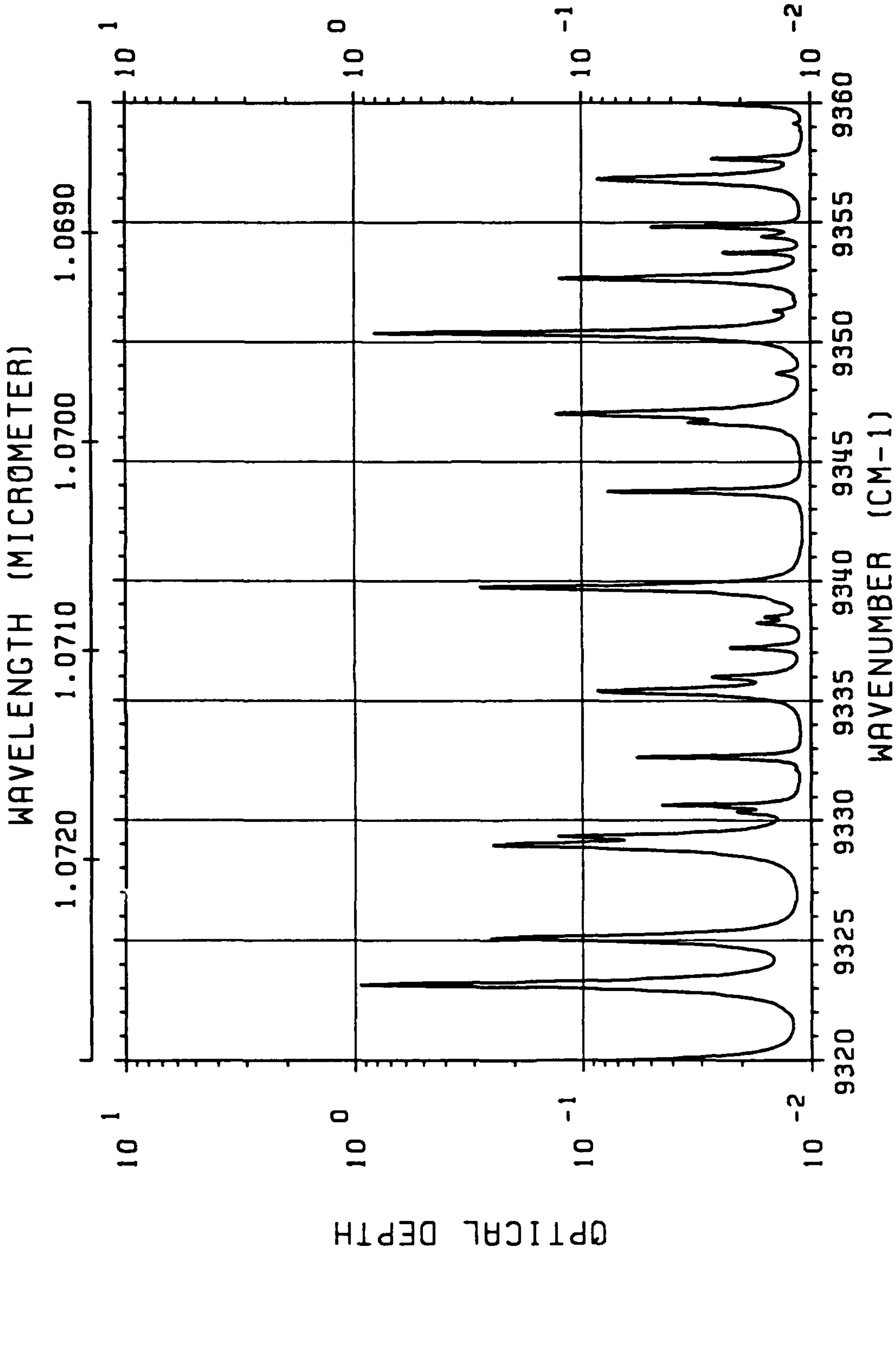


WAVELENGTH (MICROMETER)
1.0910
1.0900
1.0890
1.0880
1.0870
WAVENUMBER (CM-1)
9160
9165
9170
9175
9180
9185
9190
9195
9200
OPTICAL DEPTH
SEA LEVEL MIDLATITUDE SUMMER

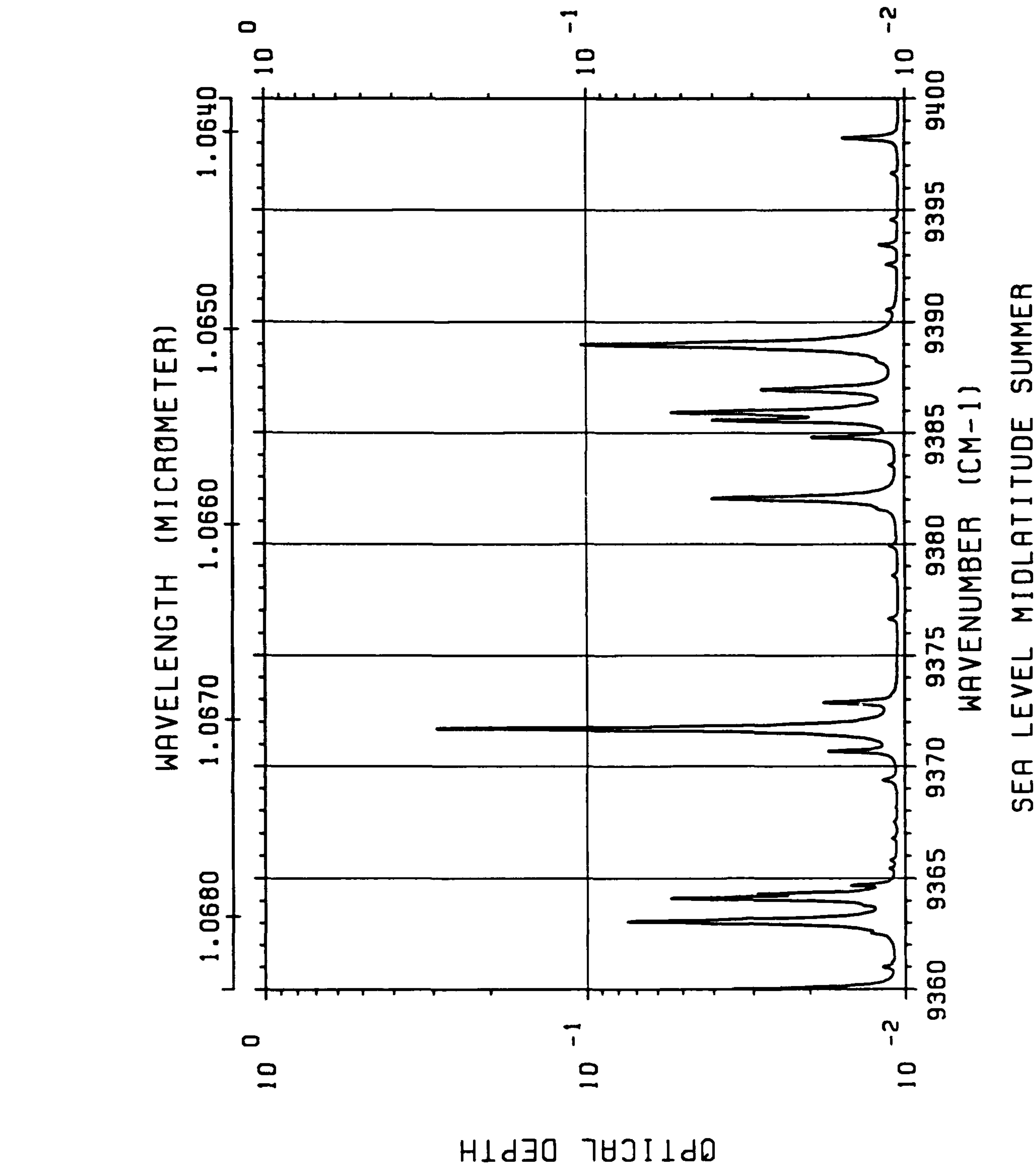

WAVELENGTH (MICROMETER)
1.0830
1.0840
1.0850
1.0860
10^1
10^0
10^-1
10^-2
9200
9205
9210
9215
9220
9225
9230
9235
9240
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH

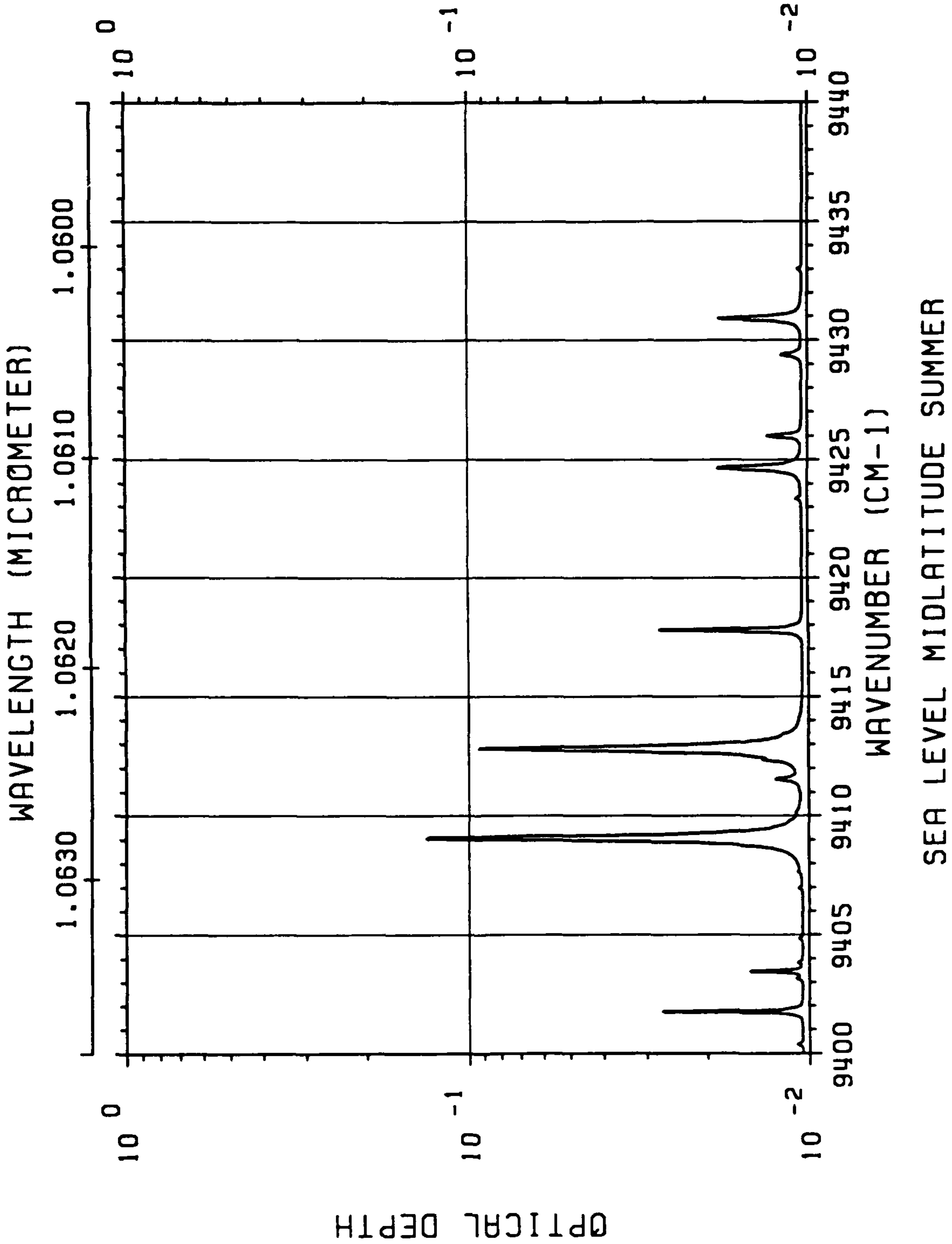

WAVELENGTH (MICROMETER)
1.0780
1.0790
1.0800
1.0810
1.0820
10^1
10^0
10^-1
10^-2
9280
9275
9270
9265
9260
9255
9250
9245
9240
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH

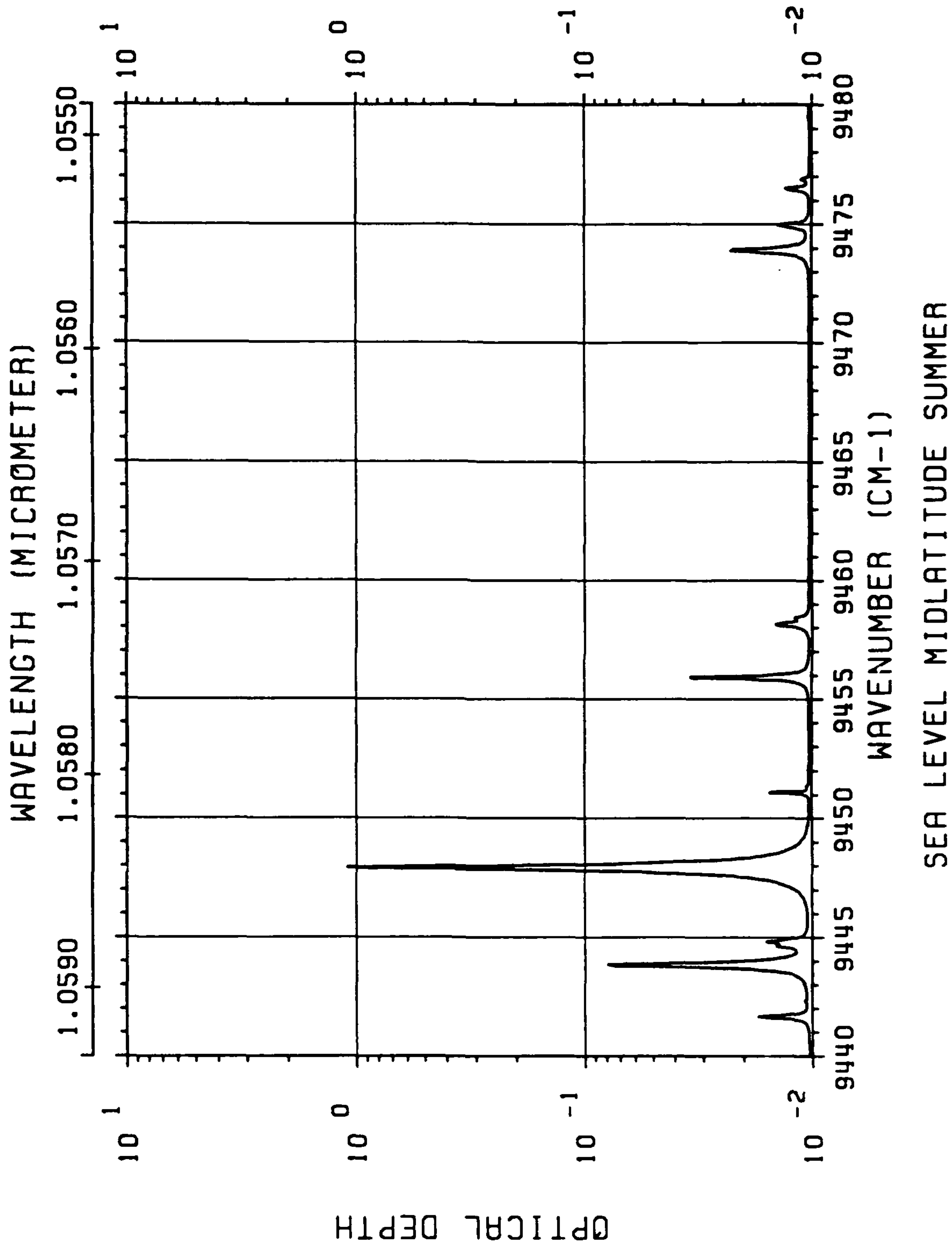

WAVELENGTH (MICROMETER)
1.0730
1.0740
1.0750
1.0760
1.0770
WAVENUMBER (CM-1)
9280
9285
9290
9295
9300
9305
9310
9315
9320
OPTICAL DEPTH
10^1
10^0
10^-1
10^-2
SEA LEVEL MIDLATITUDE SUMMER

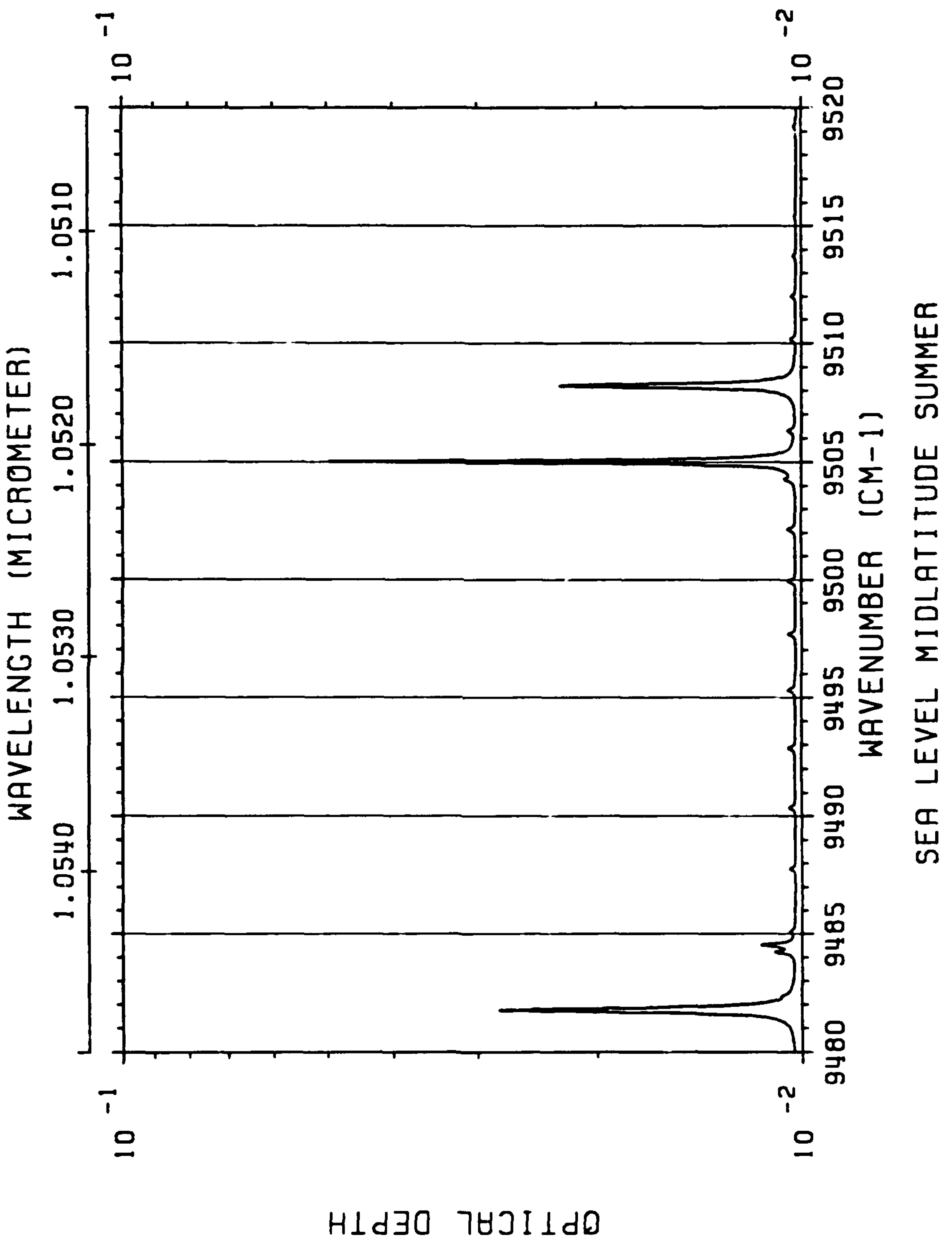


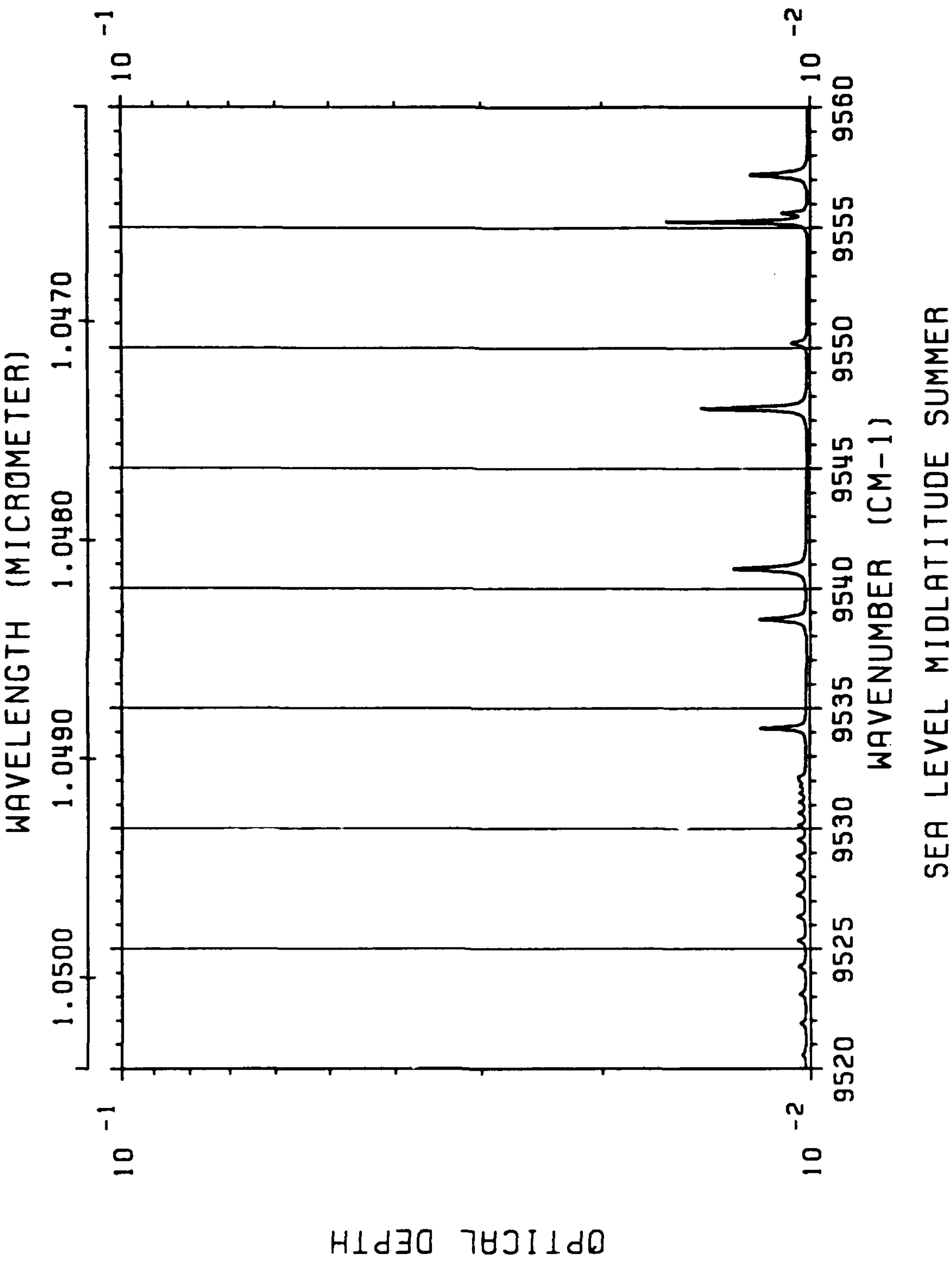
SEA LEVEL MIDLATITUDE SUMMER

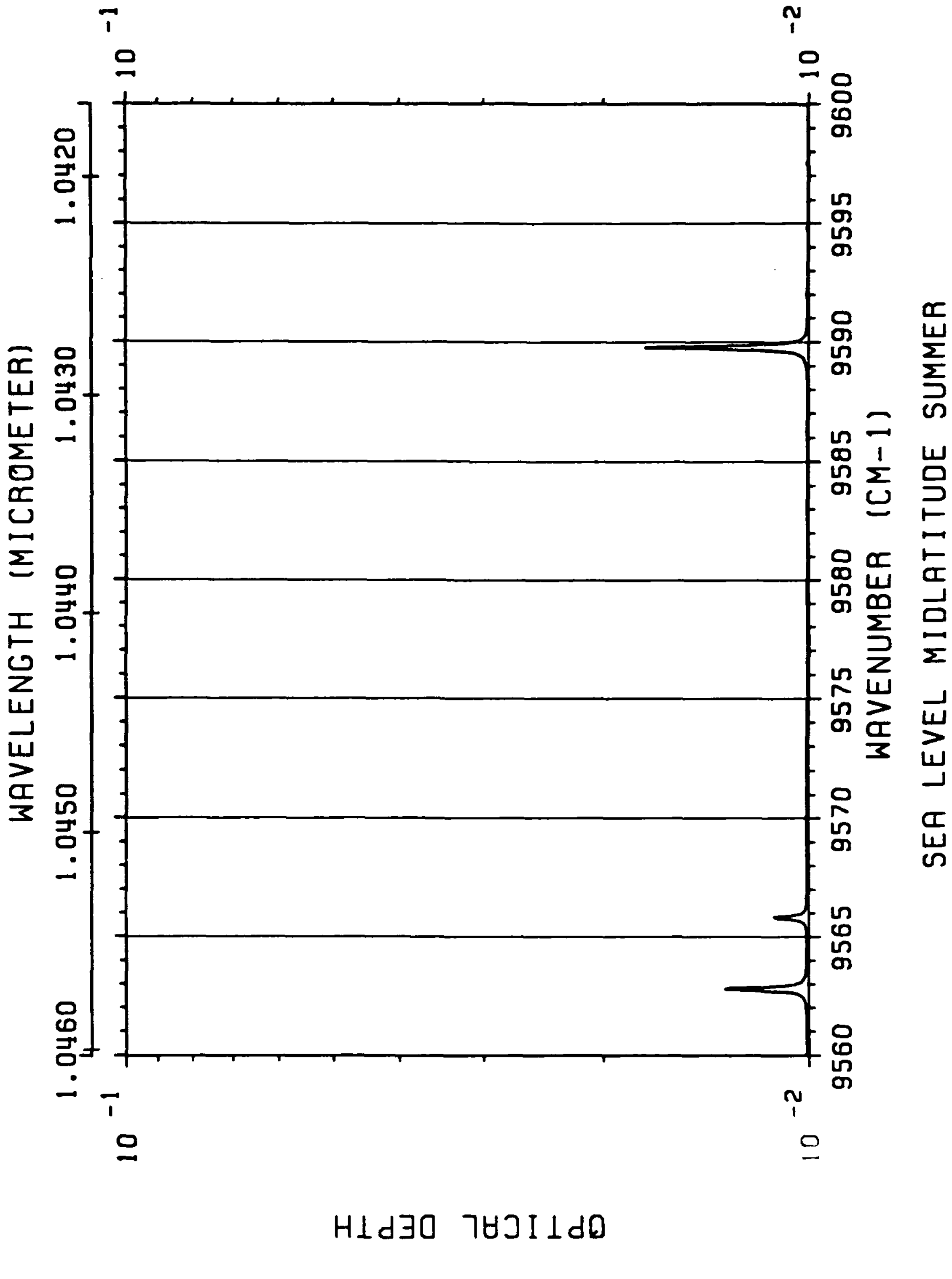

WAVELENGTH (MICROMETER)
1.0640
1.0650
1.0660
1.0670
1.0680
10 0
10 -1
10 -2
9400
9395
9390
9385
9380
9375
9370
9365
9360
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH


WAVELENGTH (MICROMETER)
1.0600
1.0610
1.0620
1.0630
OPTICAL DEPTH
10^0
10^-1
10^-2
9400
9405
9410
9415
9420
9425
9430
9435
9440
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

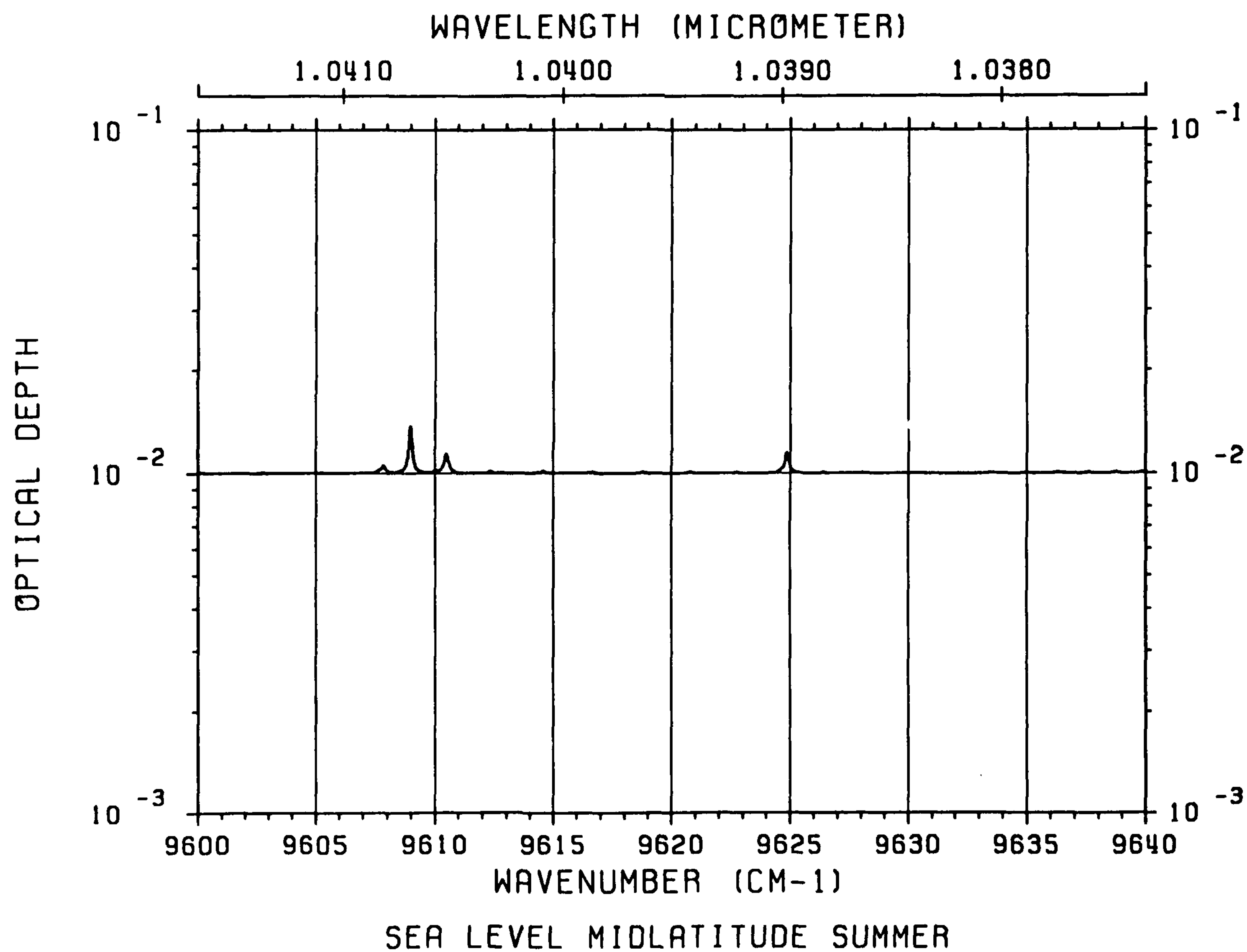

WAVELENGTH (MICROMETER)
1.0550
1.0560
1.0570
1.0580
1.0590
WAVENUMBER (CM-1)
9440
9445
9450
9455
9460
9465
9470
9475
9480
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{1}
10^{0}
10^{-1}
10^{-2}

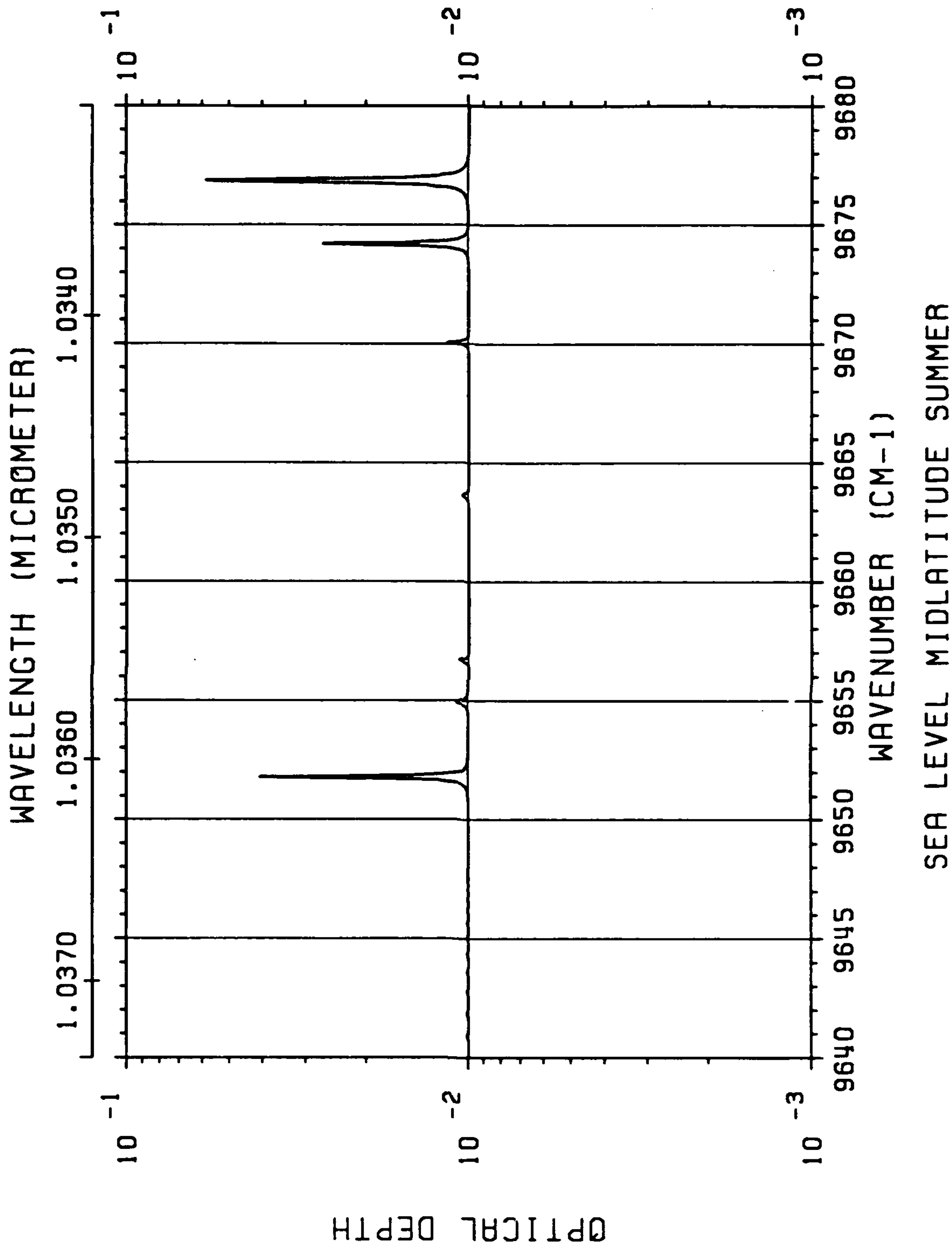

WAVELENGTH (MICROMETER)
1.0510
1.0520
1.0530
1.0540
WAVENUMBER (CM-1)
9480
9485
9490
9495
9500
9505
9510
9515
9520
10^-1
10^-2
OPTICAL DEPTH
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.0470
1.0480
1.0490
1.0500
WAVENUMBER (CM-1)
9520
9525
9530
9535
9540
9545
9550
9555
9560
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{-1}
10^{-2}

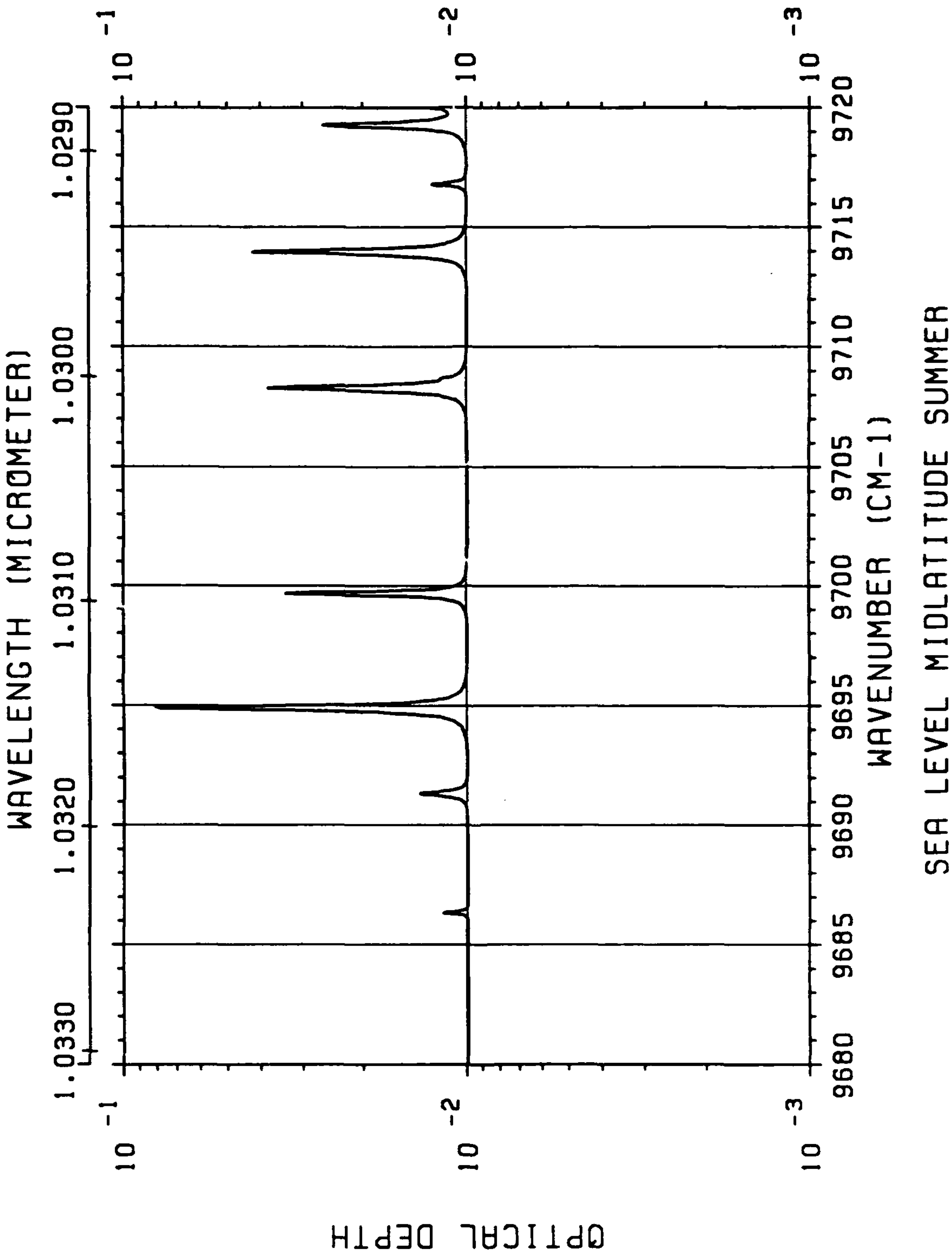


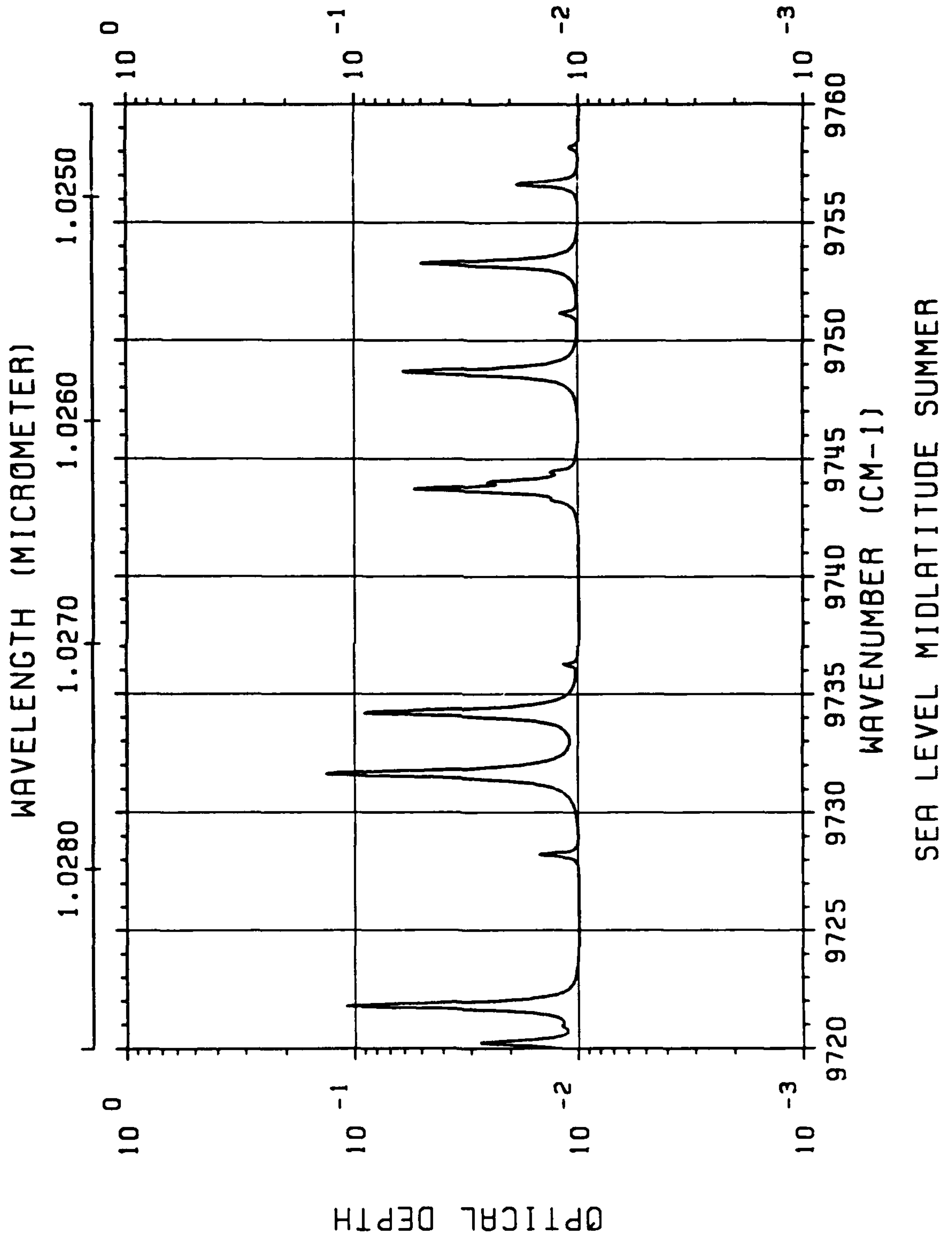
WAVELENGTH (MICROMETER)
1.0420
1.0430
1.0440
1.0450
1.0460
9560
9565
9570
9575
9580
9585
9590
9595
9600
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH

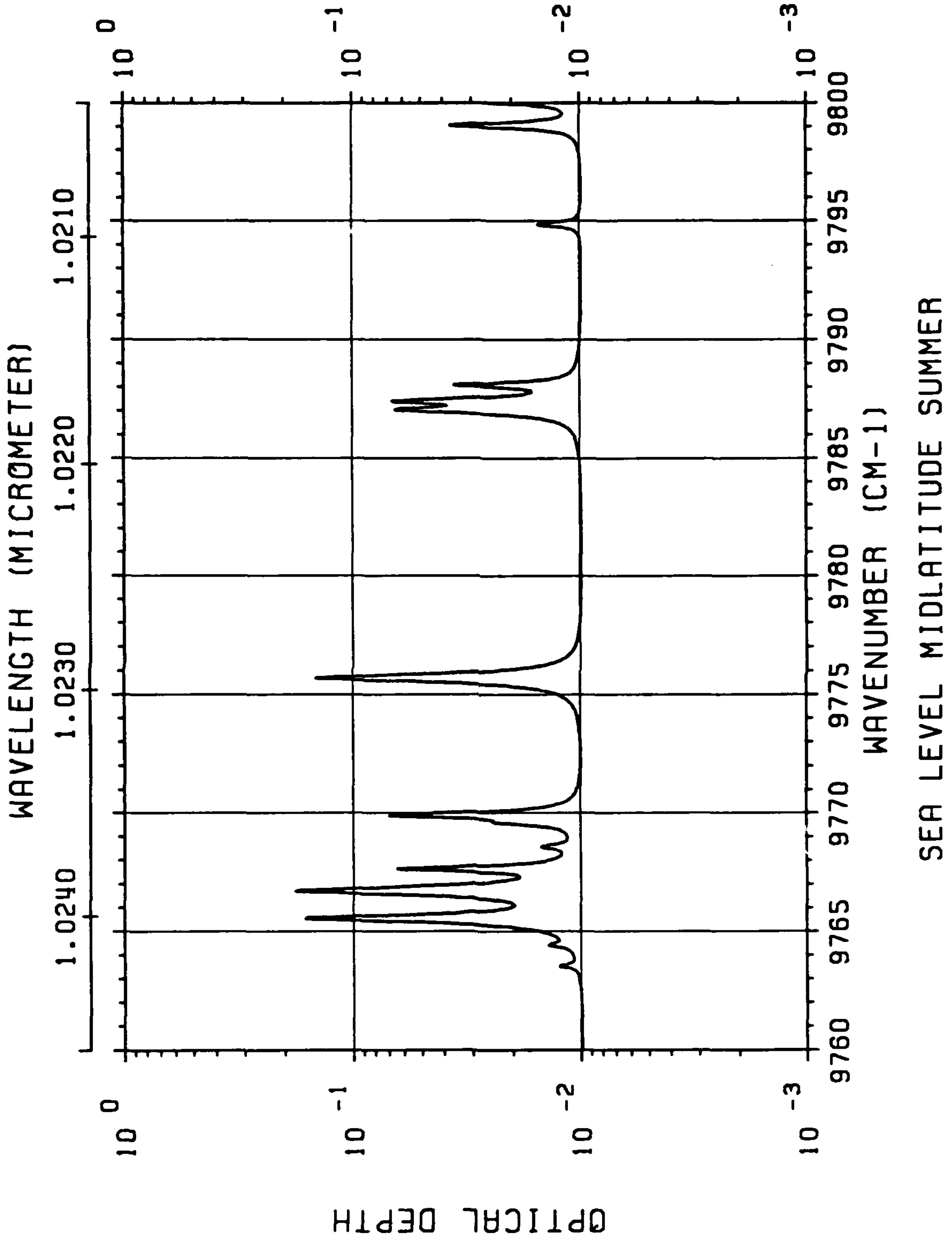

WAVELENGTH (MICROMETER)
1.0410
1.0400
1.0390
1.0380
OPTICAL DEPTH
10 -1
10 -2
10 -3
9600
9605
9610
9615
9620
9625
9630
9635
9640
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

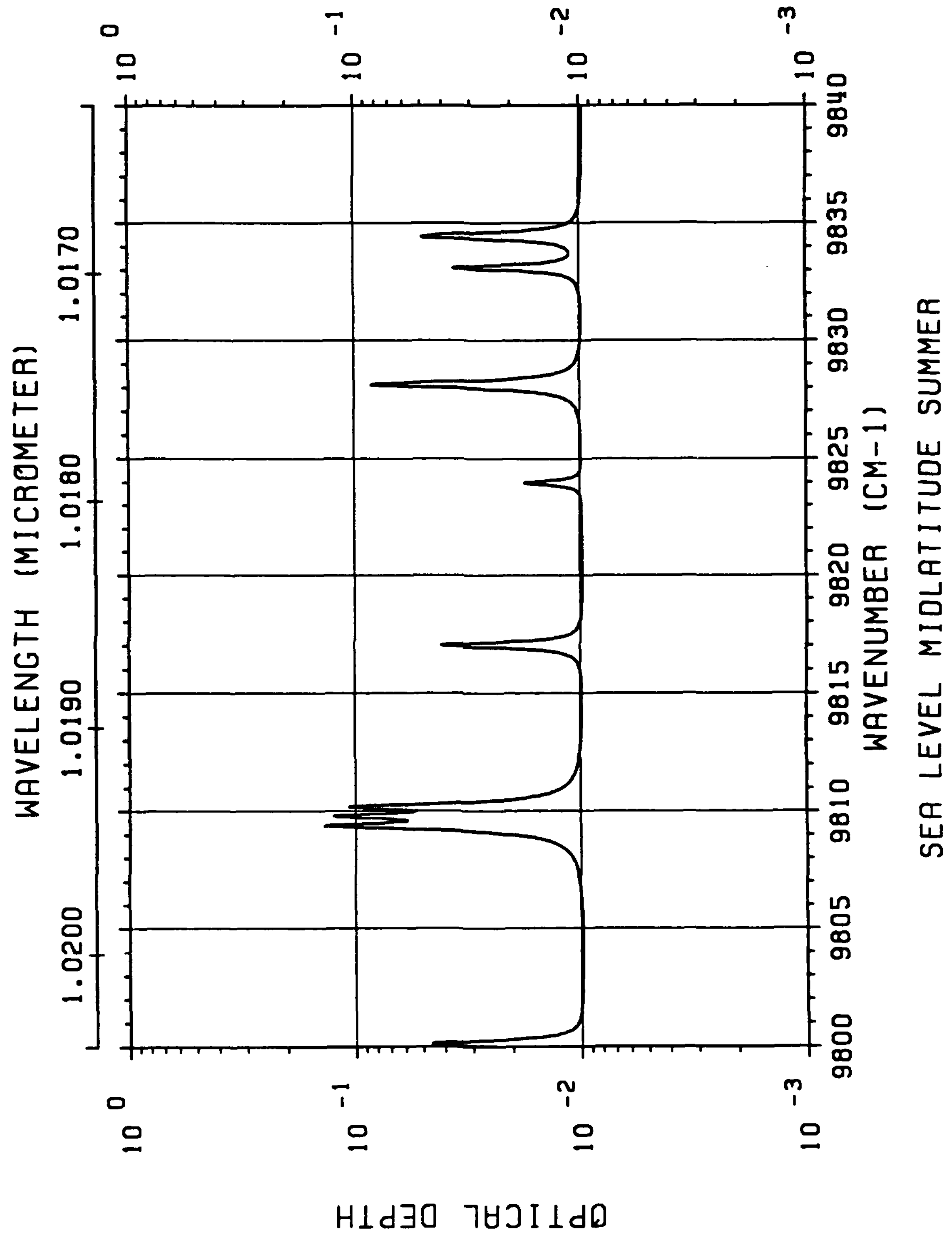


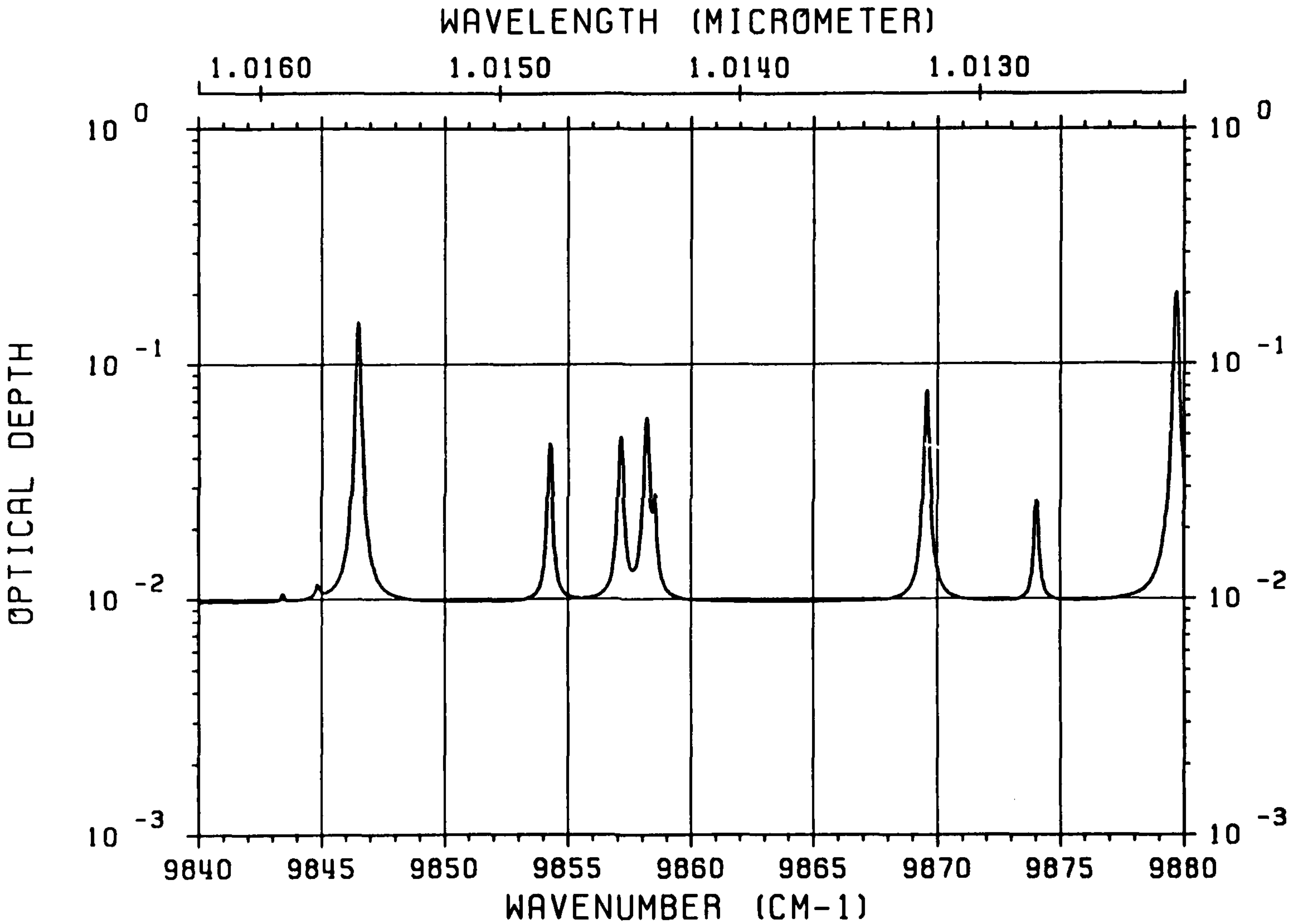
WAVELENGTH (MICROMETER)
1.0370
1.0360
1.0350
1.0340
9640
9645
9650
9655
9660
9665
9670
9675
9680
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
10^{-1}
10^{-2}
10^{-3}
OPTICAL DEPTH


WAVELENGTH (MICROMETER)
1.0290
1.0300
1.0310
1.0320
1.0330
9720
9715
9710
9705
9700
9695
9690
9685
9680
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
10^-1
10^-2
10^-3
OPTICAL DEPTH

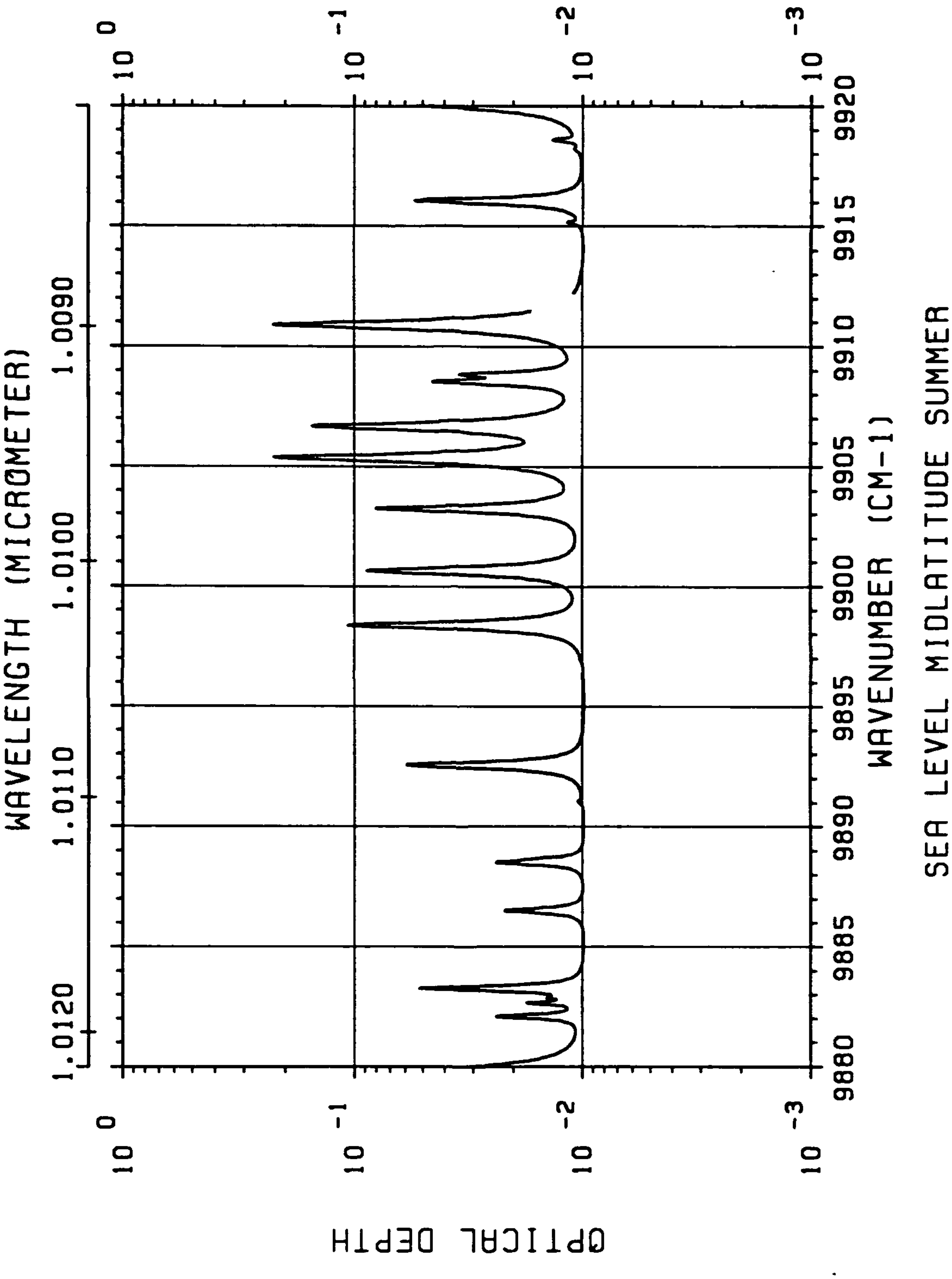

WAVELENGTH (MICROMETER)
1.0250
1.0260
1.0270
1.0280
10^0
10^-1
10^-2
10^-3
9720
9725
9730
9735
9740
9745
9750
9755
9760
WAVENUMBER (CM-1)
OPTICAL DEPTH
SEA LEVEL MIDLATITUDE SUMMER

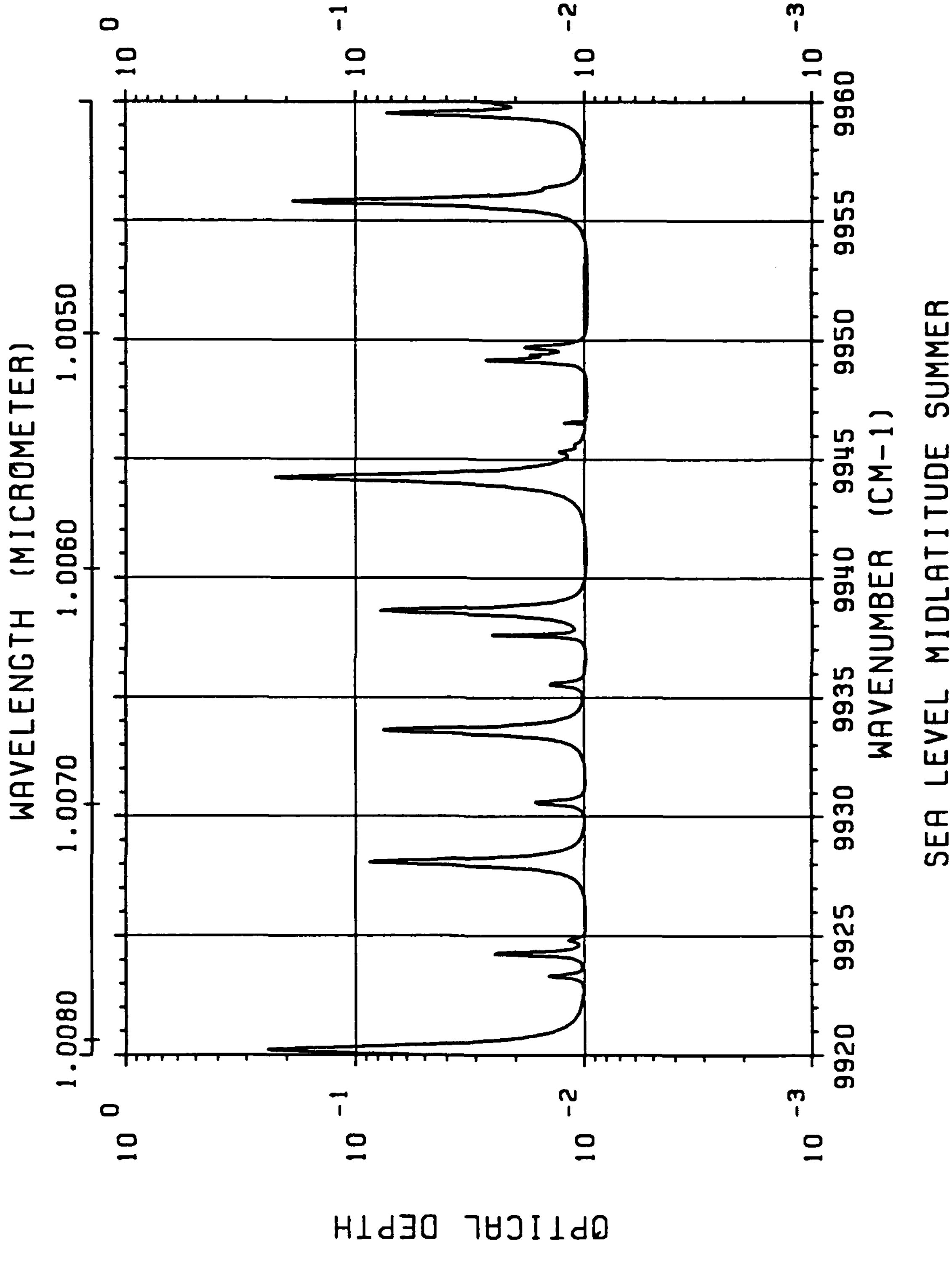

WAVELENGTH (MICROMETER)
1.0210
1.0220
1.0230
1.0240
OPTICAL DEPTH
10^0
10^-1
10^-2
10^-3
9800
9795
9790
9785
9780
9775
9770
9765
9760
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER

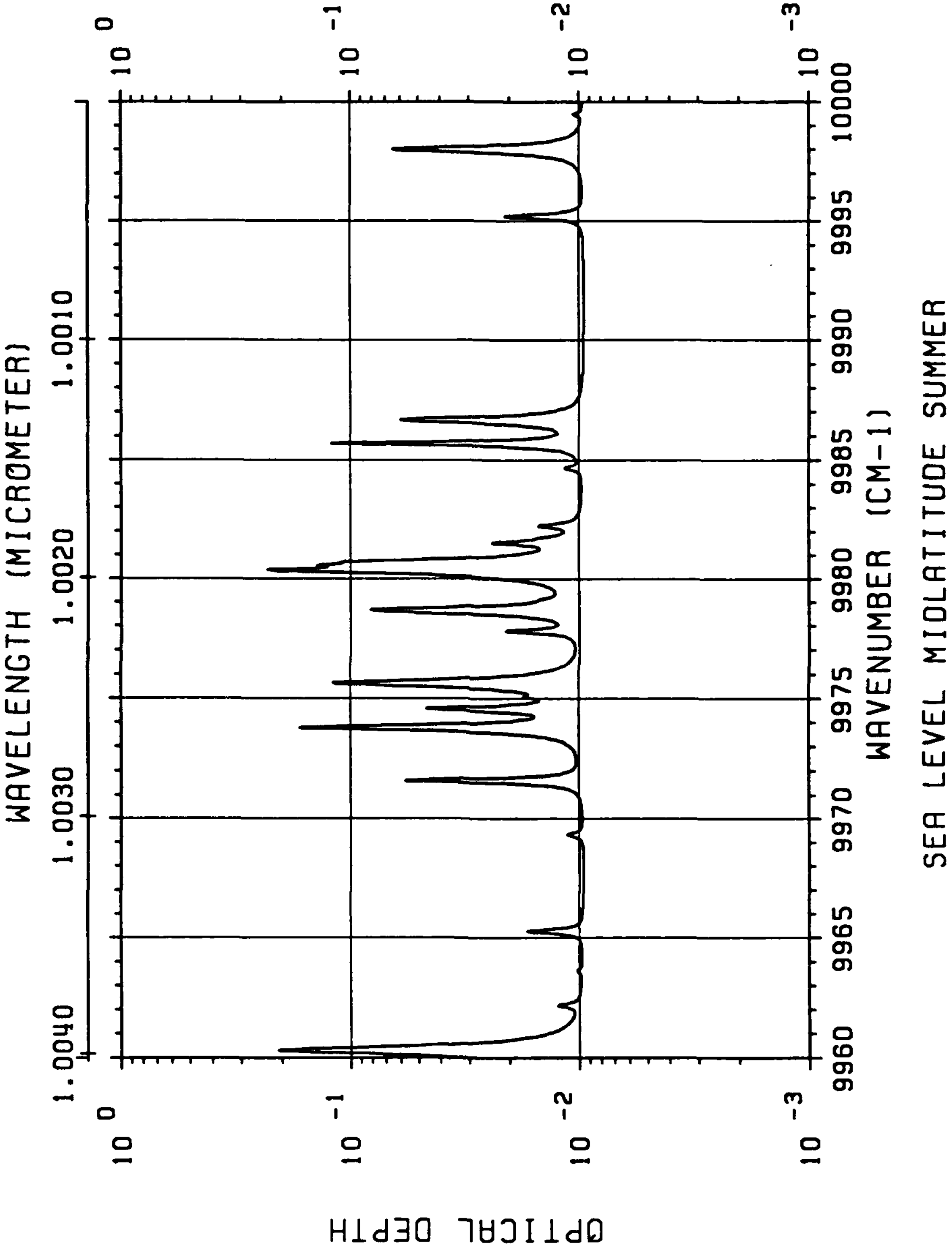

WAVELENGTH (MICROMETER)
1.0170
1.0180
1.0190
1.0200
9840
9835
9830
9825
9820
9815
9810
9805
9800
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
10^{0}
10^{-1}
10^{-2}
10^{-3}
OPTICAL DEPTH



SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.0090
1.0100
1.0110
1.0120
9880
9885
9890
9895
9900
9905
9910
9915
9920
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{0}
10^{-1}
10^{-2}
10^{-3}


WAVELENGTH (MICROMETER)
1.0080
1.0070
1.0060
1.0050
OPTICAL DEPTH
10^0
10^-1
10^-2
10^-3
9920
9925
9930
9935
9940
9945
9950
9955
9960
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER


WAVELENGTH (MICROMETER)
1.0040
1.0030
1.0020
1.0010
9960
9965
9970
9975
9980
9985
9990
9995
10000
WAVENUMBER (CM-1)
SEA LEVEL MIDLATITUDE SUMMER
OPTICAL DEPTH
10^{0}
10^{-1}
10^{-2}
10^{-3}